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THESIS

A STATISTICAL ANALYSIS OF LOS ANGELES CLASS OPTAR EXPENDITURES BETWEEN PACIFIC FLEET HOMEPORTS

by

Joseph C. Rysavy

June 2007

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For the past several years, average OPTAR expenditures for Los Angeles class submarines have differed between their three homeports in the Pacific Ocean. In an attempt to justify expenditures or find efficiencies, three statistical analyses were performed to verify these differences.

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I. INTRODUCTION

A. BACKGROUND

At the end of Fiscal Year 2006, the comptroller for the Pacific Fleet Submarine Force (SUBPAC) found the average Operating and Support (specifically, Operating Target or OPTAR) costs at his three fast attack ports looked like this:

Certified Obligations for Pacific Fleet Submarines FY 2006 (Numbers in thousands of U.S. dollars)		
Location:	Average for Repair Parts	Average for Other Expenses
Pearl Harbor (17 boats)	1,494	197
San Diego (5 boats)	1,335	184
Guam (3 boats)	1,419	171

Table 1.1. 2006 SUBPAC Certified Obligations for Los Angeles Class Units[1]

From these averages, based upon FY 2006 aggregate data, the question was asked:

- Why is the average OPTAR spent on boats in Pearl Harbor more than the average OPTAR spent on boats in Guam or San Diego?

The comptroller has seen several consecutive years of higher average spending levels at Pearl Harbor versus the other two fast attack submarine ports he is responsible for.

In FY 2006, the OPTAR spent on repair parts and other expenses varied widely when comparing individual boats. This large variance is one plausible answer to the above question. A statistical analysis of the expenditure populations with hypothesis testing would reveal if significant statistical differences exist or if the differences are within the margin of statistical error. Looking at unit level data by year, the OPTAR that each boat spends seems to be random with no obvious year-to-year correlations. These fluctuations may be caused by several variables.

[1] CDR Chip Zawislak, e-mail message to author, October 27, 2006.

B. RESEARCH DISCUSSION

The research question was: Is there a statistically significant difference between OPTAR spending totals at different homeports in the Pacific Fleet?

To answer this, we proceeded as follows:

- First, the cost data set had to be identified, collected and normalized
- Second, ship homeport data were obtained
- Third, the cost data set and the homeport data were input to a database
- Fourth, the statistical analysis was performed
- Fifth, ship underway data were obtained and analyzed with regression

Initially, the data set had to be identified and collected. The data of interest, as identified by the SUBPAC comptroller, fall into three spending categories:

- Repair OPTAR: Expenditures on Parts and Repairables
- Other OPTAR: Funds spent on contracts, rentals, postage etc.
- Total OPTAR: The sum of Repair OPTAR and Other OPTAR

The comptroller provided these data in the form of Certified Obligation Reports dating back to FY 2002.

The Certified Obligation Reports from 2002-2005 did not provide a large enough sample to perform an adequate statistical analysis. The Visibility and Management of Operation and Support Costs (VAMOSC) Database was used to increase the size of the data set. To ensure proper cost categories were used, the comptroller's data were compared to the spending categories in the VAMOSC database. The VAMOSC information allowed the addition of several years of data to the samples.

Next, ship homeport data were obtained. The comptroller provided a list of Unit Identification Codes (UIC's) and homeport data. These data were provided from 1996 to 2006.

Once the data set was established, hypothesis testing was used to analyze the data. Three statistical tests were performed. The first was the Student-t test. This parametric test is used to compare population means and it is based upon strict assumptions of the

nature of the data distribution. The second test was the Wilcoxon rank-sum test. This is a non-parametric test which provides a similar population comparison as the Student-t test but does not have the corresponding stringent assumptions. Finally, the data were analyzed using regression with panel data. This analysis was performed twice. The first run used homeport data as the sole independent variable. The second run added underway data as an independent variable.

The underway data were obtained from the Operating Tempo (OPTEMPO) spreadsheets provided by Commander, Submarine Force Pacific, (COMSUBPAC).

C. SCOPE

This study is an independent look at the costs of operating Los Angeles Class Submarines in the U.S. Pacific Fleet, with the goal of finding statistically significant differences of OPTAR expenditures between the three homeports.

Los Angeles class (LA class) submarines were the only platform considered in this analysis. Ohio Class and Seawolf Class submarines were not included, due to the differences in their structure, operating schedules and operating philosophies.

The analysis was performed at the aggregate level, that is, with boats grouped by location. The analysis neither delved into command specific purchasing policies nor performed reviews of individual unit purchases. The goal of the aggregate analysis was too identify areas for further research.

A comparison between budget estimates and actual spending was not performed. The only data looked at were actual expenditures, not the estimates.

D. ORGANIZATION

1. Chapter II – Literature Review

Chapter II discusses OPTAR. It presents background information on the funding stream from the Operations and Maintenance Appropriation down to the operating units. A list of the items that units can spend their OPTAR on is provided.

Chapter II presents information regarding the use of VAMOSC. Included is a discussion of the strengths and weaknesses of VAMOSC provided information.

Finally, the three statistical tests are briefly described.

2. Chapter III – Data Gathering and Normalization

Chapter III presents the method of gathering data. This chapter describes the two different OPTAR reports provided by the comptroller and the cross-matching performed between the comptroller's OPTAR reports and the VAMOSC database. This cross-matching allowed the data set to expand. The processes of gathering the homeport data and OPTEMPO data are both described.

Chapter III also discusses the normalization of the data set. The data were normalized to account for ships that switched homeports in the period researched. The data were also normalized for inflation. The data set was output in Constant 2006 dollars using the inflation indices in VAMOSC.

3. Chapter IV - Statistical Analysis of Cost Data

This chapter provides a statistical analysis of the data set and samples. The three statistical tests are described and applied.

First, summary statistics for the populations and their samples are presented. Then, the Student-t test is used to compare the populations based upon their samples. The Wilcoxon rank-sum test is presented next. Finally, regression with panel data is used to analyze the data set with homeport data and underway data.

4. Chapter V – Other OPTAR Cost Element Structures

Chapter V breaks the Other OPTAR populations into their constituent parts. It presents two different vertical analyses of the Other OPTAR expenditures. The first application provides average spending levels for each of the Other OPTAR categories using all of the data points for each homeport. The second application presents the vertical analysis by year. The first analysis shows what the typical boat from a particular

port would spend in each of the categories that make up Other OPTAR. The second analysis shows how this spending has changed over time.

5. Chapter VI – Conclusions and Recommendations

The final chapter summarizes the findings of the research, and explains the answer to the question: "Is there a statistically significant difference between OPTAR spending totals at different homeports in the Pacific Fleet?"

Four recommendations are provided based upon the results of the statistical tests.

Finally, if cost drivers can be determined, two areas for further research are suggested.

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II. LITERATURE REVIEW

A. OPTAR FROM APPROPRIATION TO UNIT

Operating Target, or OPTAR, is provided to Naval units for expenses which arise from their routine operations. OPTAR starts within the Operations and Maintenance (O&M) portion of the Defense appropriation. These funds filter down from The Department of the Navy, Financial Management and Comptroller (NAVCOMPT/N-82), to Commander, Pacific Fleet, (COMPACFLT) to the Type Commander (TYCOM). In this case, Commander, Submarine Force, Pacific (COMSUBPAC) is the Type Commander for the Submarine Forces in the Pacific Fleet. COMSUBPAC has responsibility for submarine force readiness, including training, maintenance and logistics involving Pacific units.[2]

1. Commands under COMSUBPAC

COMSUBPAC oversees many commands. He is responsible for fast attack and ballistic missile submarines, as well as auxiliary submarines (deep submersibles), submarine tenders and the submarine Intermediate Maintenance Activities across the Pacific Ocean.[3]

2. From TYCOM to Squadrons

OPTAR funds are distributed from the SUBPAC comptroller to the submarine Squadrons and Groups each quarter.[4] Figure 2.1 displays the flow of OPTAR funds from OM&N appropriation to the units.

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[2] Navy Department, Financial Management Instruction, COMSUBLANT/COMSUBPACINST 7330.5A (Pearl Harbor, HI: 2000), 1-3, 1-7.

[3] Ibid., 1-13.

[4] Ibid., 2-3.

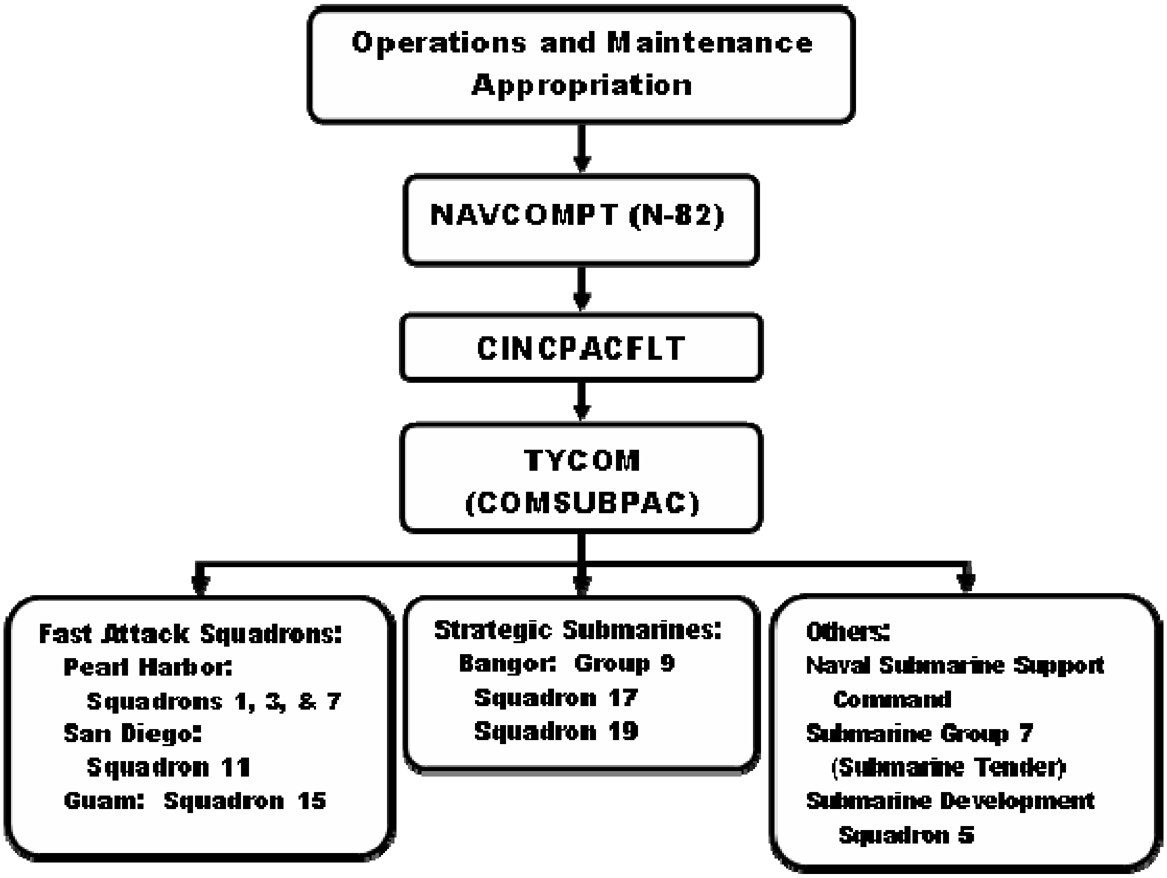

Figure 2.1. Flow of OPTAR funds from OM&N appropriation to Units[5]

B. MISSION READINESS AND OTHER SHIP OPERATIONS

Operations and Maintenance money is divided into several Activity Groups and Sub Activity Groups (AG/SAG's). The 1B1B Sub Activity Group involves the category of Mission Readiness and Other Ship Operations. The 1B1B category is divided into several subprograms, but the two which are relevant to this thesis are Repair OPTAR and Other OPTAR.[6]

Repair OPTAR (Abbreviation: SR)

Repair parts purchased with Repair OPTAR are items which have equipment application and appear in appropriate ship's documents. Having an equipment

[5] COMSUBLANT/COMSUBPAC INST 7330.5A. 1-3, 1-7.

[6] Ibid., 1-7.

application means the repair part is required by the ship for organization level preventive or corrective maintenance. Approved documents are: the Ship's Allowance Parts List (APL), Stock Number Sequence List (SNSL), Integrated Stock List (ISL), approved drawings or manufacturer's handbooks. Specifically, these items could include general purpose hardware, metals, lumber and lubrication oil and grease when used for maintenance actions.[7]

Other OPTAR (Abbreviation: SO)

Other OPTAR includes all the other areas of day-to-day operational spending. Items purchased under this category are hull and structural maintenance and preservation materials; equipage items such as Damage Control appliances and tools; petroleum, oil and lubricants (used for maintenance); medical/dental supplies. Other OPTAR also provides funding for contracted services (eg. telephone, port utilities, chartering tugs, vehicle rental.)[8]

OPTAR Reports

In the Budgeted OPTAR Report (BOR) provided by the SUBPAC comptroller, both Repair OPTAR and Other OPTAR are further subdivided into several more fund codes. This provides an additional level of detail to see what goes into the two broad spending categories. The following sections provide descriptions of these fund codes.

Fund Codes for Repair OPTAR

There are three OPTAR Fund codes that, when summed, total Repair OPTAR. These are fund codes M3, MB and MR.[9] Table 2.1 has a description for each:

---

[7] COMSUBLANT/COMSUBPAC INST 7330.5A. 1-7.

[8] Ibid., 1-8.

[9] Ibid., 2-3.

Fund Code	Title	Description
M3	NSA AVDLR MATERIALS (Navy Stock Account Aviation Depot Level Repairables)	Aviation depot level material purchased by the Ship Forces part of operating forces
MB	NSA Non-AVDLR	Non-aviation depot level material in the Navy Stock Account, used to accomplish organizational level maintenance
MR	Equipment maintenance related material – NSA Type Repair Parts	Repair Parts used in the performance of organizational level maintenance on ship's equipment

Table 2.1. OPTAR Fund codes for Repair Parts[10]

Fund Codes for Other OPTAR

In the BOR, the Other OPTAR category was broken into 23 Fund Codes. Several of these codes are not used by the operating units (the Submarines). They are listed in the report for the use of the other commands COMSUBPAC is responsible for, namely the various Pacific Fleet Intermediate Maintenance Activities, the Deep Submergence Unit and staffs.

The Navy has published an operating procedure (NAVSO P-3013-2) which has descriptions of the fund codes and an instruction (COMSUBLANT/COMSUBPAC INST 7330.5A) that provides the procedures for assigning the fund code categories. When the ship's force requests items that are paid for out of OPTAR funding, the storekeepers must assign an OPTAR fund code to that request. The 7330.5A instruction assists them with this assignment. A brief description of each relevant fund code is in Table 2.2:

Fund Code	Description
MC	Consumables – Material Used in day to day operations
MD	Vehicle Rental – Rental or hire of a passenger vehicle
ME	Equipage – Navy Stock Account, durable, end use equipment with value >$100

[10] Navy Department, Financial Management of Resources, Operating Procedures, NAVSO P-3013-2 (Washington, DC: 1990), A-II-60 – A-II-66.

Fund Code	Description
MJ	ADP Requirements – All operation and maintenance costs for purchase, acquisition and lease of Automated Data Processing equipment
MK	Charter Hire Tugs/Pilots – Costs of tugs, pilotage and other port services in non-Navy ports
ML	Combat Terrorism / Force Protection
MS	Communications Services – Long distance telephone, postage, PO Boxes etc.
MU	Other services – Ashore services, laundry, equipment repair, boat rental etc.
MV	Printing and Publications – Costs associated with printing
MW	Purchased Utilities – Utilities purchased by operating forces based ashore
MY	ADP other than equipment – Used for purchasing software
M2	AV DLR Material – All Navy Stock Material purchased for use in hull and structure maintenance. Includes paints, tools, sanitary, habitability and others.
M6	Hazardous waste disposal
M7	Medical/Dental – Material requisitioned for medical purposes
M8	Special storage HHG
M9	POL other – Petroleum, Oil, Lubrication used aboard for purposes other that propulsion

Table 2.2. OPTAR Fund codes for "OPTAR other" Division[11]

Since the assignment of the end use OPTAR fund codes is left up to the supply division onboard, there may be some variability, or even mistakes in the recording of data.

C. THE NAVY VAMOSC DATABASE

The Naval Center for Cost Analysis (NCCA) supports and maintains the Navy's Visibility and Maintenance of Operating and Support Costs Database (VAMOSC). The VAMOSC database is used primarily by cost estimators to allow them access to historical

[11] NAVSO P-3013-2. A-II-60 – A-II-71.

Operating and Support costs and to estimate future O&S costs for current and future weapons systems. It can also be used to identify cost drivers of existing systems or for the performance of cost research projects.[12]

VAMOSC has ship level data collected back to 1984. Its data are broken into several different databases, each with an accompanying User's Manual which provides descriptions of the cost categories found within that database. The database used for this research was the Ships Database, which provides Operating and Support Cost data for all reporting platforms.

One advantage of the VAMOSC database is the ability to automatically apply inflation rates. The VAMOSC output asks the user if they want their data in "Then Year Dollars" or "Constant Year dollars." By placing the output in constant year dollars, the user can quickly compare inflation adjusted expenditures between years.

Another advantage of the VAMOSC database is the breadth of the data gathered in the database. The VAMOSC support team obtains its information from over 130 data sources. Cost data are collected from a wide variety of sources including the STARS-HCM database[13] the 3M system[14], and the Navy Energy Usage Reporting System (NEURS). The VAMOSC database also has a quality assurance function that checks values which seem excessively high or low. Analysts verify these extreme data before uploading to the database.[15]

The Ship's Database provides four categories of data broken into multiple levels. The primary category used in this research was the Direct Unit Cost category. The total for Direct Unit Cost is a summation of three spending sub-categories: Personnel, Unit Level Consumption, and Purchased Services. Most of the OPTAR funds were found under the Unit Level Consumption and Purchased Services categories. The Personnel category is not covered under OPTAR funds and therefore did not apply to this research.

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[12] "About VAMOSC." Lkd. at "Navy VAMOSC." http://www.navyvamosc.com/ [13 May 2007].

[13] STARS-HCM: Standard Accounting and Reporting System-Headquarters Claimant Module.

[14] 3M information is gathered through the Open Architecture Retrieval System (OARS) database.

[15] VAMOSC Ships User Manual vers 5.2 (IBM: 30 June 2006), E-2.

For this research, only a narrow slice of the data found in the VAMOSC database was used. The categories accessed from the Ship's Database and their descriptions from the Ship's Database User Manual are listed in Table 2.3, below:

Element # - Name	**Element Description**
1.2.2.1 - Repair Parts and Repairables	Cost of non-aviation depot level repairable and repair parts for use in maintenance of the ship and installed equipment.
1.2.1.2 - POL Other	Cost of POL used for other than ships propulsion and ships service
1.2.3.1 - Equipment	Items not classified as consumables or repair parts. Included are items of equipage that require management control afloat due to any one of a combination of high unit cost, vulnerability to pilferage, and/or importance to ships' mission. Examples include binoculars and electronics test equipment.
1.2.3.2 - Consumables	Costs for supplies charged to the ship and not specifically included in other elements. Includes administrative and housekeeping items, medical and dental supplies, routine maintenance tools not specifically related to, but which may be used in the repair of equipment and equipage, and general-purpose hardware.
1.3.1 - Printing and Copying Services	Cost incurred by the ship for procurement of printing and publications not carried in standard government stock.
1.3.2 - ADP Rental and Contract Services	Cost of rental of automatic data processing equipment and related contractual services. This element also includes costs of other services purchased by the ship and not covered elsewhere including laundry services, rental of boats, and port services provided by non-Navy activities.
1.3.4 - Telephone and Postal Services	Cost of long distance telephone services, postage (excluding parcel post), rental of post office boxes, and telephone installation charges.
1.1.3 - TAD	Cost of ships' personnel travel for training, administrative or other purposes such as homeport travel entitlement, special aircraft charter, crew rotation/deployment and temporary shore patrol. It consists of costs such as commercial transportation charges, rental of passenger carrying vehicles, mileage allowances, and subsistence including per diem and incidental travel expenses.

Table 2.3. Ship's Users Database Costs – Element Numbers and Names[16]

[16] VAMOSC Ships Users Manual vers 5.2, 21-28.

Comparing Tables 2.1, 2.2 and 2.3 reveals one of the problems encountered with using VAMOSC. The VAMOSC database does not provide as much granularity as does using the OPTAR fund codes. Many of the VAMOSC categories are summations of a few of the OPTAR funding categories. For example, VAMOSC spending category 1.3.2 - ADP Rental and Contract Services is a roll-up of ADP rentals along with ashore contracts, boat rental and port services. The OPTAR fund codes break this into MJ (ADP requirements), MK (Charter Hire), and MU (Other services). This drawback is addressed in Chapter III.

Another problem with VAMOSC is the lack of "time granularity". The expenditures in VAMOSC are for the full fiscal year. Through VAMOSC there is no possibility to look at expenditure rates or expenditures by months. This fact becomes important in this analysis because several boats shifted homeport during the years in question. Much of the time, this homeport shift did not happen exactly at the turn of a new fiscal year. The VAMOSC data were not used for years of "split homeports" because they reflected spending from both ports.

The fund codes for Temporary Additional Duty (TAD) are not used by the units. Temporary Additional Duty is paid by the Groups or Squadrons and not paid out of the ship's OPTAR. [17] The exception to this is vehicle rental. If a vehicle is rented while on TAD, that expense is paid out of the ship's OPTAR funds under fund code MD. In VAMOSC, the category that displays this vehicle rental expense is 1.1.3 – TAD.[18] This is the reason why this cost category is included in the make up of Other OPTAR.

D. STATISTICAL ANALYSIS

Three statistical tests were performed on the data set. These were the Student-t test, the Wilcoxon rank-sum test and regression with panel data.

Initially, data were organized to provide a top level analysis. Descriptive statistics for the samples of the Total OPTAR, Repair OPTAR and Other OPTAR populations

[17] COMSUBLANT/COMSUBPAC INST 7330.5A. 2-14.

[18] VAMOSC Ships Users Manual vers 5.2, 21.

were calculated. Each top level population was divided into three more populations. These were defined by homeport. These homeport samples were compared to each other using the parametric Student-t test. This analysis is explored further in Chapter IV.

Further statistical analysis was done using the non-parametric Wilcoxon rank-sum test. The Wilcoxon rank-sum test does not rely upon the normal distribution. When sample sizes are small there may not be enough evidence to show that a distribution is normal. The Wilcoxon rank-sum test relies only on the order of the data, not on the shape of the data. This non-parametric testing provides a flexibility and robustness not found in the Student-t test. The Wilcoxon rank-sum test procedure is outlined in Chapter IV.

The final statistical analysis was regression with panel data. Regression with panel data observes individual ships across multiple years and provides regression coefficients for the chosen independent variables. This analysis was performed twice, once with homeport data and once with underway data.

The following chapter describes how the data were gathered, what data were considered relevant and how that data were normalized. It also provides the justification for using only the data found on VAMOSC.

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III. OBTAINING AND NORMALIZING DATA

There were four data sets obtained through the course of this research:

- The SUBPAC comptroller provided two different types of OPTAR expenditure reports, the Budgeted OPTAR report (BOR) and the Certified Obligation Report (COR).
- First, VAMOSC was queried to confirm the data in the BOR and COR and then to provide the entire OPTAR data set.
- The comptroller provided homeport data for the years of research.
- Schedule data were obtained from COMSUBPAC Operations.

A. COMPTROLLER PROVIDED EXPENDITURE REPORTS

1. Budgeted OPTAR Report (BOR)

The BOR is an annual report which shows the total OPTAR expenditures for each boat in the two categories of concern. These two categories are Repair OPTAR (SR) and Other OPTAR (SO). The BOR subdivides these "rolled up" categories into several different fund codes. This division of the two broad categories into the various fund codes was discussed in Chapter II.

The BOR was useful because it provided detailed expenditure data for each individual boat. The BOR was divided such that each squadron got its own page and each boat was listed individually on that page. The BOR was used to determine and cross check the exact VAMOSC elements which made up the SR and SO spending categories. This cross check is discussed later in this chapter. The main weakness with the BOR was that only one was available (FY 2006).

2. Certified Obligation Reports (COR)

The comptroller provided CORs for FY2002-2006. These spreadsheets listed each boat with the total amount spent on OPTAR during that fiscal year. This total amount was broken into the amount of OPTAR spent on SR and SO. These spreadsheets divided the boats by squadron. Therefore, each boat's homeport location could be

verified with these spreadsheets. However, the COR, provided only three data points for each boat in any particular year. Comparing the BOR and COR:

- The BOR provided good detail whereas the COR only had the roll up numbers.
- Both the COR and the BOR were helpful in determining the relationship between VAMOSC data and the comptroller provided data.

B. VAMOSC PROVIDED DATA

The VAMOSC Ship's database was the primary source of cost data for all statistical analysis. Once it was determined the comptroller data were the same information as could be obtained from VAMOSC, VAMOSC was chosen as the sole source of data. The accuracy and ease of output of the VAMOSC system added to its attraction as the primary data source.

To ensure a uniform VAMOSC output, some standard query criteria were established. To ensure spending comparisons were not affected by inflation, all cost output was in "Constant FY 2006 dollars". Fiscal years 1996 and greater were selected. Finally, only the Los Angeles Class hull numbers (SSN-688 and greater) in the Pacific Fleet were chosen for output.

Once the applicable VAMOSC elements were determined, the database was queried and the expenditure data were input directly into a Microsoft Access Database with fields for fiscal year, spending category and the hull number.

The process used to determine the applicable VAMOSC spending elements is described in Part E of this Chapter.

C. COMPTROLLER PROVIDED HOMEPORT DATA

Homeport data were provided by the comptroller dating back to fiscal year 1996. The considerations of this data set follow.

Homeport data were difficult to find. There was no one source that listed each submarine, its homeport and the specific time at which it performed a homeport transfer. The data gathering was also complicated by the fact that COMSUBRON 15 (Guam) was

stood up in FY 2000 and commenced being used as a submarine homeport starting in FY 2002. Also, there were several boats which shifted homeports from San Diego to Pearl Harbor or to Guam through the course of the 11 years of data that were studied.

The comptroller provided Unit Identification Code (UIC) data which listed each Pacific Fleet submarine squadron with its homeport and assigned boats. Each fiscal year had its own page and the page was "current" as of the first of October, of that fiscal year. This data set spanned from fiscal year 1996 to fiscal year 2006.

For the most accurate output, it was imperative that a ship's homeport transfers were taken into account when building the homeport data set. Since VAMOSC only provides a full fiscal year's worth of spending data, homeport records had to be scrutinized and rejected if it appeared the ship split its time between two different homeports during that particular year. Boats generally didn't shift homeports at the start of the fiscal year.

In the Microsoft Access database each boat had an individual entry for every year it was in the Pacific Fleet. Each of these boat-years in the database had a column provided to input the homeport from the UIC sheets. Once entered in the database, a single boat's year-to-year entries were compared. If it appeared a unit switched homeports sometime in that year, further investigation was performed to determine the exact date of the switch. If the investigation showed the boat switched homeports in the middle of the fiscal year, then the homeport entry was left blank. Without a homeport in the database, a properly formulated query would not count that year as a data point. In this fashion the homeport data were obtained and normalized.

D. OPTEMPO DATA

Another piece of data are the OPTEMPO data which displayed each ship's employment. This was provided in a Microsoft Excel spreadsheet on the classified internet. It had two levels of detail. The Level One Analysis simply displayed the number of days a ship spent underway and in port. The Level Two Analysis distinguished between days underway deployed, days underway local, days in port-homeport and days in port-major overhaul. The quarterly data were summed to ensure

full fiscal years of data were used. The schedule data were merged with the homeport and expenditure data on the classified internet and analyzed.

E. CROSS-REFERENCING COMPTROLLER EXPENDITURES TO VAMOSC ELEMENTS

The abundance of cost data found in VAMOSC made it a desirable source of data. If VAMOSC could be used to provide the same information (SR and SO) as found in the CORs and BOR, then even more data points could be obtained and analyzed. This chapter ends with a description of how VAMOSC data were verified to correspond to the comptroller provided data. This was an essential step in the research as it allowed for gathering even more data for the statistical analysis.

Cross referencing VAMOSC and comptroller provided data was done by comparing the VAMOSC output and comptroller provided figures. Strong relationships were observed between VAMOSC and both the SR and the SO categories.

1. Cross Referencing the SR Category to VAMOSC

Initially, the FY 2006 COR was compared to the FY 2006 BOR. The values for the SR and SO totals matched in both reports.

The BOR showed that three OPTAR fund codes compose the SR OPTAR category. These were the M3, MB and MR fund codes. These fund codes (described in Chapter II) all involve material purchases for organizational maintenance. There are several elements in the VAMOSC Ship's database which provide spending data for maintenance materials. VAMOSC was queried to output each one of these material-related spending elements for each Pacific Fleet boat, for FY 2005, in "then year" dollars. (Comptroller data were provided in then year dollars.) The VAMOSC report was compared to the FY 2005 COR. One VAMOSC category exactly matched the SR total in the COR. This was the VAMOSC Element number "1.2.2.1-Repair Parts and Repairables". Table 3.1 provides an example of the data from 2005 from Squadron one based in Pearl Harbor. For the full 2005 comparison, see Appendix A.

			Columns practically identical	
			COMPTROLLER	VAMOSC
COMSUBRON ONE			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 688	LOS ANGELES	20202	933	935,940
SSN 701	LA JOLLA	20826	1300	1,300,427
SSN 698	BREMERTON	20882	1036	1,034,568
SSN 715	BUFFALO	20996	1130	1,129,548
SSN 766	CHARLOTTE	21763	1311	1,310,886
SSN 772	GREENEVILLE	21831	1288	1,288,124

Table 3.1. Comparison of Comptroller Provided SR and VAMOSC Spending Element 1.2.2.1 for the year 2005.

The comparison between the comptroller provided OPTAR for Repair Parts and the VAMOSC database Element 1.2.2.1 showed a very strong similarity between both sets of numbers. FY 2002 was chosen for a similar comparison.

The VAMOSC Element 1.2.2.1 was queried for FY 2002 data. This was output in Then Year (2002) dollars and compared to the 2002 SR data from the comptroller. Table 3.2 provides an example of the data from 2002 from Squadron One based in Pearl Harbor. For the full 2002 data set, see Appendix A.

			Columns practically identical	
			COMPTROLLER	VAMOSC
COMSUBRON ONE			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2002)**	**(TY $ 2002)**
SSN 688	LOS ANGELES	20202	563	562,644
SSN 701	LA JOLLA	20826	1,119	1,118,650
SSN 715	BUFFALO	20996	853	850,284
SSN 766	CHARLOTTE	21763	746	745,564
SSN 772	GREENEVILLE	21831	848	848,136

Table 3.2. Comparison of Comptroller Provided SR and VAMOSC Spending Element 1.2.2.1 for the year 2002.

The “Then Year” adjusted values are convincing. With the VAMOSC data element printed out in “Then Year” dollars, and compared to the comptroller data, it is clear the data come from the same source. The conclusion is that the VAMOSC Ship’s Database Element number “1.2.2.1-Repair Parts and Repairables” is the VAMOSC representation of the comptroller’s SR (Repair OPTAR). The conclusion is that both sets of data came from the same source. Therefore, we could query VAMOSC for years prior to FY 2002 (which was the earliest data provided by the comptroller). Figure 3.1 is a representation showing the relationship between the SR (Repair OPTAR), its respective OPTAR fund codes, and the VAMOSC spending element 1.2.2.1:

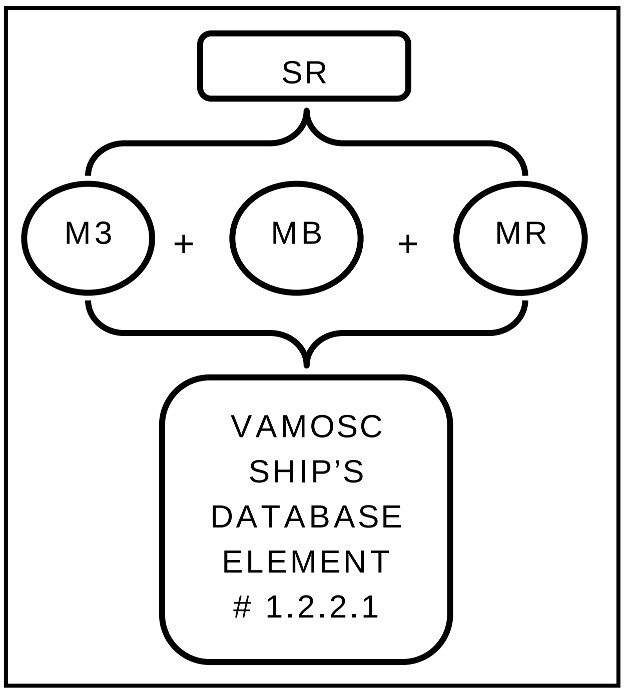

Figure 3.1. Repair OPTAR connection to VAMOSC Element 1.2.2.1

2. Cross Referencing the SO Category to VAMOSC

The 2006 BOR showed several different OPTAR fund codes that composed the SO OPTAR (Other OPTAR) category. The fund codes relevant to Los Angeles class submarines are listed in Chapter II, Table 2.2.

The first step to finding a relationship between VAMOSC spending elements and the Other OPTAR category was to figure out which of the 240+ VAMOSC Ship's Database elements were in the same category as the Other OPTAR category. Michael Carey from the NCCA provided guidance by stating the actual OPTAR related costs in the VAMOSC Ship's Database were limited to sub-elements of 1.2 (Unit Level Consumption) and 1.3 (Purchased Services). The noun descriptions of the various sub-elements were compared to the OPTAR fund codes which comprised the Other OPTAR category. Many of these descriptions were very similar.

The cross check between Other OPTAR and VAMOSC was done by picking five different cases (five different boats.) The check looked at their VAMOSC outputs from each year from FY 2002 to FY 2005 and compared them to the Other OPTAR data provided by the comptroller. Seven VAMOSC sub-elements, when added together, closely matched the Comptroller's values for SO. These VAMOSC categories are listed in Table 3.3 below:

1.1.3 – TAD	1.3.1 - Printing and Copying Services
1.2.1.2 - POL Other	1.3.2 - ADP Rental and Contract Services
1.2.3.1 – Equipment	1.3.4 - Telephone and Postal Services
1.2.3.2 – Consumables	

Table 3.3. VAMOSC Categories which, when summed, equal SO

The five boats compared were the SSN 688, the 705, the 721, the 759 and the SSN 773. These boats were picked because each one was in a different squadron for the time period from FY 2002 to FY 2005. The output for the SSN 705 is provided in Table 3.4:

Corpus Christi: SSN 705	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	45	0	8,551	Provided by VAMOSC
1.2.3.1 Equipment	21,637	24,627	26,483	
1.2.3.2 Consumables	152,133	199,892	141,890	
1.3.1 Printing & Copying Services	0	13,402	7,415	
1.3.2 ADP Rental & Contract Services	35,823	5,991	2,947	
1.3.4 Telephone & Postal Services	16,492	7,250	8,367	
1.1.3 TAD	1,834	0	444	
Total of VAMOSC provided data:	227,964	251,162	196,097	Total from VAMOSC
OPTAR other (SO)	228,000	251,000	196,000	Provided by Comptroller

Table 3.4. SSN 705, VAMOSC spending data compared to SO (FY03 – FY05)

Table 3.4 shows a direct relationship between the OPTAR other category provided by the comptroller and the sum of the seven VAMOSC sub-elements. All five of these cases are provided in Appendix B.

The final challenge to linking the VAMOSC sub-elements and the OPTAR other category was to make connections to the OPTAR fund codes. The Ship's Database provided seven different categories of Other OPTAR spending and a relationship was sought between the VAMOSC sub elements and the OPTAR fund codes listed in the BOR.

Since the FY 2006 BOR was the only one provided, this cross check analysis could only be done for that year. It was accomplished by comparing the BOR and the 2006 VAMOSC output and finding the VAMOSC sub-elements that exactly matched the OPTAR fund code data and the sub-elements that were summations of multiple OPTAR fund codes.

This process used the "guess-and-check" method. The one–to-one matches were easy to find because they were straightforward. The summation elements were a little more difficult to connect, but once a good fit was found for them, the summation was applied to the other four case boats with success. Table 3.5 shows the relation between the VAMOSC expense elements on the left to the OPTAR fund codes on the right:

Corpus Christi: SSN 705	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	177	176.70	M9
1.2.3.1 Equipment	8,716	8,715.91	ME+MJ
1.2.3.2 Consumables	164,239	161,202.31	MC+M7+M2
1.3.1 Printing & Copying Services	7,361	7,166.37	MV
1.3.2 ADP Rental & Contract Services	3,816	2,742.75	MU
1.3.4 Telephone & Postal Services	3,851	3,515.72	MS
1.1.3 TAD	6,291	6,381.04	MD

Table 3.5. SSN 705, VAMOSC spending elements to OPTAR Fund Codes (FY06)

Finding a direct relationship between VAMOSC data and comptroller data was a very important revelation. The links to the VAMOSC database expanded the data available for analysis. If UIC data would have been available back to 1984, even more observations could have been included in the data set. These connections to the VAMOSC database allowed the data set to span from FY 1996 to FY 2006, a full 11 years worth of data.

Figure 3.2 is a representation of the linkages between the Other OPTAR category, its respective fund codes and the VAMOSC database elements:

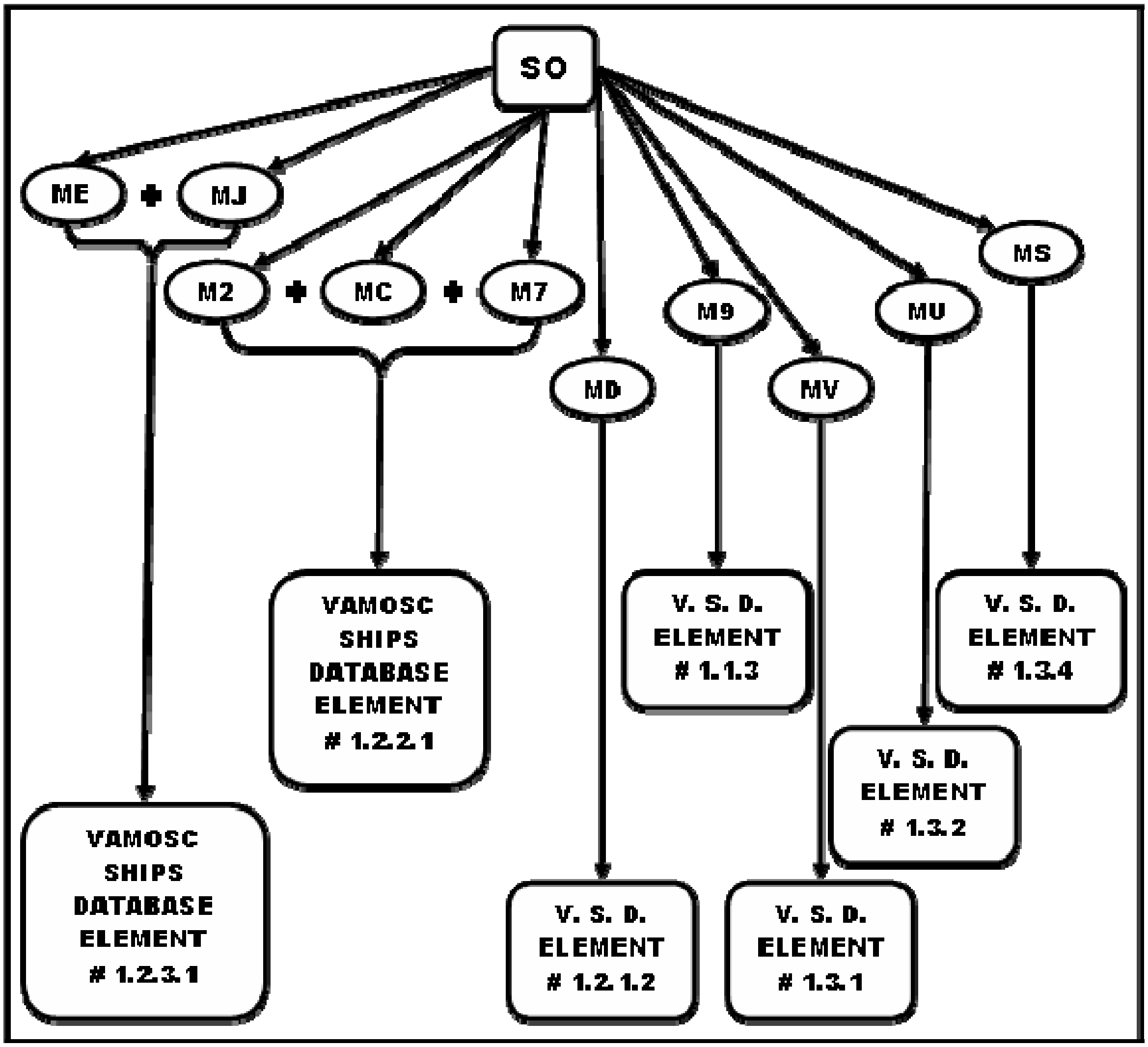

Figure 3.2. OPTAR Other connection to VAMOSC Ship Database (V.S.D.) Elements

The statistical analysis of the data set is presented in Chapter IV.

IV. STATISTICAL ANALYSIS OF COST DATA

Statistical analysis was done in three phases. The first phase looked at the measures of central tendencies, at various levels to try to figure out if significant statistical differences existed. This involved looking at the mean and standard deviation for the population and associated samples. The method used a parametric test, the Student-t test of means to see if the samples came from the same population. The second set of statistical analysis used the non-parametric test, the Wilcoxon rank-sum test, applied to each year of data to find significant differences. The Wilcoxon rank-sum test was also applied to the same populations as the Student-t test as a non-parametric alternative. This test assumed the expenditure values were not normally distributed. Finally, regression with panel data was used to see if another statistical test could show differences between ships at different locations.

A. MEASURES OF CENTRAL TENDENCIES AND STUDENT T-TEST

This analysis started with a top level look at the population parameters. This “Level One” analysis looked at the three overall spending categories: Total OPTAR, Repair OPTAR and Other OPTAR. This top level analysis presents the statistical nature of these three spending categories.

The “Level Two” analysis drew samples of these populations by port. For each of the three populations, three samples were drawn, one for each port. The Student t-test was applied to these samples to determine if their means were significantly different.

In general, the data points collected for each of these spending categories are considered samples of the larger populations. The true population of Total OPTAR expenditures would encompass prior years’ spending (since LA class submarines have been in use since the late 1970’s) and extend to future years’ spending data points. Therefore, in the following paragraphs, the population means are presented as intervals, since the samples are being used to make inferences about the populations.

The following section presents the sample means and standard deviations for the aggregate levels of Total OPTAR, Repair OPTAR and Other OPTAR. The intervals for each population mean are calculated using the t-estimator function. Finally, for each sample, it presents the probability distribution of the data points in a histogram.

The methods of this analysis, including the z-estimates and Student-t tests are taken from Statistics for Management and Economics, by Gerald Keller.[19]

1. Level One – The Samples and their Populations

a. Total OPTAR

This is the top level look at the Total OPTAR category. Since Los Angeles Class submarines have been operating since the late 1970's, the data available for Total OPTAR (from FY 1996 to FY 2006) were considered a sample of the Total OPTAR population. Table 4.1 presents the descriptive statistics for these samples from Microsoft Excel:

Total OPTAR Sample (1996-2006)	Parameter Value (FY'06 $)
Sample Size (n)	260
Mean (x-bar)	1,608,882
Median	1,578,718
Mode	N/A
Standard Deviation (s)	537,946
Standard Error	33,362

Table 4.1. Measures of Central Tendency and Dispersion (Total OPTAR, from 1996-2006 in FY '06$)

There were 260 observations between FY 1996 and FY 2006. The point estimate for the average yearly Total OPTAR expenditure from any boat in any port was $1.6 million (FY 06$) and the center observation is $1.578 million (FY 06$). The median and mean are very close, the median value being about $30,000 less than the mean value. The sample had no mode because there were no repeated values.

[19] Gerald Keller, Statistics for Management and Economics (Belmont, CA: Thompson South-Western 2005), 302-324, 361-400, 413-450.

Since this is only a sample of the larger Total OPTAR population, the point estimate of the mean, in Table 4.1, is not the actual population mean. The population mean is unknown because not all of the yearly Total OPTAR expenditure points are known. To correct for this, the z-estimate of the mean was calculated. Although the population's actual mean and standard deviation are unknown the samples were large enough to allow for the z-estimate of the mean to be used.[20]

The z-estimator provided intervals of the population mean at standard confidence levels of 90%, 95% and 99%. Microsoft Excel was used to calculate the z-estimate of the mean. Table 4.2 displays these results:

Point Estimator	Interval Estimates		
Mean	Confidence Level	Lower Confidence Limit	Upper Confidence Limit
1,608,882	90%	1,554,006	1,663,757
	95%	1,543,493	1,674,270
	99%	1,522,947	1,694,816

Table 4.2. Total OPTAR population mean-point and interval estimates

The sample histogram is pictured in Figure 4.1:

[20] Keller, 363.

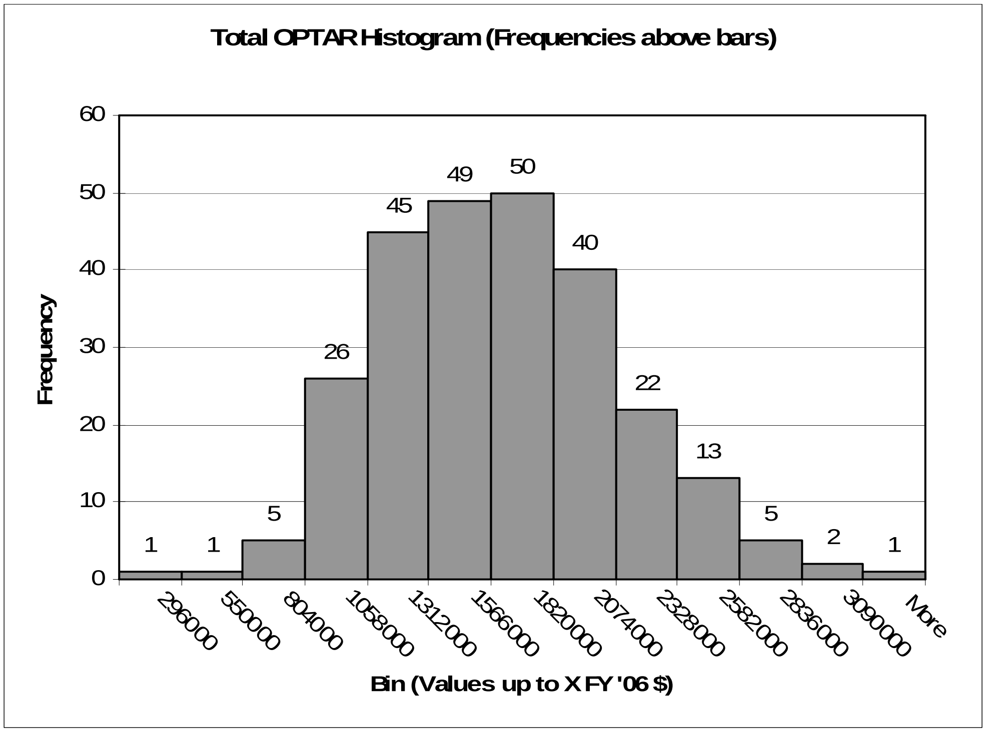

Figure 4.1. Histogram for yearly Total OPTAR

The distribution frequency in the histogram looks somewhat like the normal distribution. At the very least, the histogram does not look very non-normal.

b. Repair OPTAR and Other OPTAR

In a similar fashion, the measures of central tendency, dispersion and the histograms were generated for the Repair OPTAR and Other OPTAR populations. Table 4.2 presents the results of this analysis:

	Repair OPTAR sample (1996-2006)	Other OPTAR sample (1996-2006)
Statistic	Parameter Value (FY'06 $)	Parameter Value (FY'06 $
Sample Size (n)	260	260
Mean (x-bar)	1,306,365	302,517
Median	1,269,155	279,654
Mode	N/A	N/A
Standard Deviation (s)	497,518	128,816
Standard Error	30,855	7,989

Table 4.3. Measures of Central Tendency and Dispersion (Repair and Other OPTAR, from 1996-2006 in FY '06$)

Comparing the three samples, Total OPTAR, Repair OPTAR and Other OPTAR it is clear the majority of OPTAR funds are spent in the Repair OPTAR category. Repair OPTAR comprises 81% of Total OPTAR spending while Other OPTAR comprises only 19%.

Using the Microsoft Excel z-estimate of mean function and using the sample standard deviation as an approximation of the population mean, interval estimates of these means were calculated:

	Point Values	Interval Estimates		
	Sample Mean	Confidence Level	Lower Confidence Limit	Upper Confidence Limit
Repair OPTAR	1,306,365	90%	1,255,613	1,357,116
		95%	1,245,891	1,366,839
		99%	1,226,888	1,385,842
Other OPTAR	302,517	90%	289,376	315,657
		95%	286,859	318,175
		99%	281,939	323,095

Table 4.4. Repair and Other OPTAR population mean-point and interval estimates

These interval estimates in Table 4.4 serve some key purposes. A budgeter would be able to look at these data and calculate how much money would need to be budgeted for LA class OPTAR expenditures in the next year. Also, comptrollers and supply officers can look at these confidence intervals and point estimates and see where their boat ranks when compared to the population estimates. This could help individual units identify when they had spending efficiencies or excesses. In the current era of constrained fiscal policy, these data would provide goals or targets for ship expenditures.

Figure 4.2 is the histogram for the Repair OPTAR population. It shows there is a strong tendency toward the middle 4 categories. Seventy-five percent of the

observations (197 of 260) fall between the values of $777,000 and $1,773,000. The frequency of occurrence within each category diminishes as the spending increases. Like the Total OPTAR histogram, the Repair OPTAR frequency distribution is not noticeably non-normal. This similarity to the normal distribution and the large sample size supports the use of the sample's standard deviation for the z-estimate of the mean procedure above.

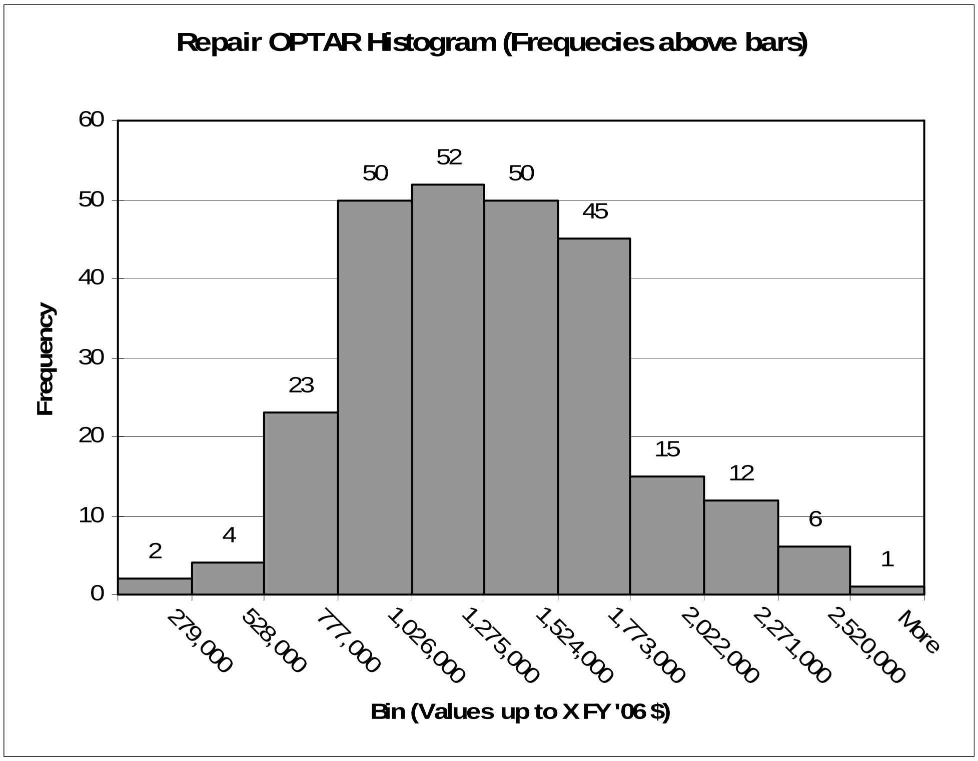

Figure 4.2. Histogram for yearly Repair OPTAR

The histogram for the Other OPTAR expenditures (Figure 4.3) is skewed to the right. This shape is expected when the variable being sampled has a lower bound but no upper bound. Expenditures follow this relationship. In the case of OPTAR, the lower bound on spending is $0 (boats cannot spend less than $0). The upper bound is set by the comptroller's quarterly OPTAR grants which may be exceeded in an extreme situation.

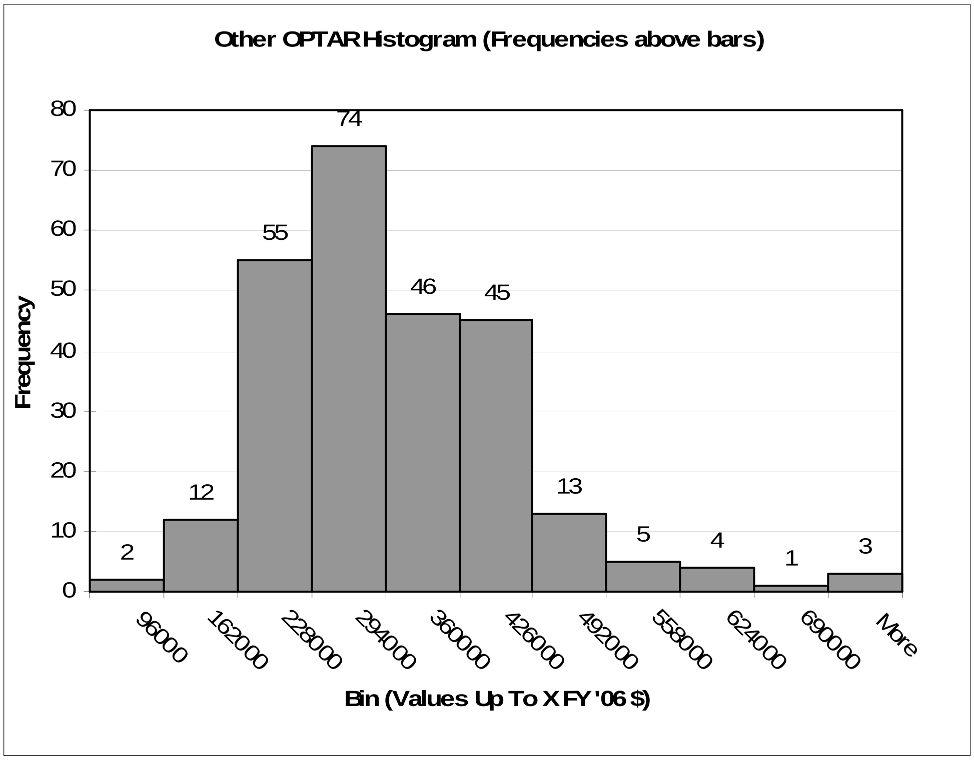

Figure 4.3. Histogram for yearly Other OPTAR

The samples of the Total OPTAR, Repair OPTAR and Other OPTAR populations provided various sample statistics, estimates of the population means and three frequency distributions which look fairly normal. Now, the three categories are broken into port populations. Each port population is sampled in a similar fashion as above, estimations of their means are made and hypothesis testing is used to compare the different port population means.

2. Level Two – Samples by Port

a. Total OPTAR Port Populations

From the Total OPTAR population, three samples were taken, one from each port. Table 4.5 summarizes their statistical parameters for Total OPTAR:

	PH Sample	SD Sample	GU Sample
Parameter	Parameter Value (FY'06 $)	Parameter Value (FY'06 $)	Parameter Value (FY'06 $)
Number of Observations	187	64	9
Mean	1,615,444	1,561,668	1,808,275
Median	1,549,811	1,580,180	1,862,710
Mode	N/A	N/A	N/A
Variance	$3.014*10^{11}$	$2.533*10^{11}$	$3.023*10^{11}$
Standard Deviation	549,020	503,306	549,842
Standard Error	40,148	62,913	183,280

Table 4.5. Total OPTAR Port Samples (1996-2006)

These descriptive statistics from the samples show boats from Guam have higher yearly Total OPTAR expenditures than the other two ports. This average, though, is based upon only 9 observations. The largest data set, Pearl Harbor, has the next highest yearly mean spending with San Diego having the lowest. The standard deviations for Pearl Harbor and Guam are almost equal and the one for San Diego is considerably less. The lower standard deviation indicates the values from San Diego are grouped closer to the mean.

Comparing the sample means (Table 4.5) to the population means (Table 4.1), the means for the Guam and Pearl Harbor samples are greater than the population mean and the San Diego sample mean is less than the population mean. Are these sample means significantly different from each other? If they were significantly different from each other, hypothesis testing would provide evidence that the samples actually came from different populations. If they were not statistically different, the difference in the sample parameters is likely due to chance.

The Two Sample Student-t test is a statistical hypothesis test which seeks to show if the differences between two sample means are due to chance or if the difference may be due to other factors.

The Student t-test was developed to use on small samples to make inferences about populations. The t-test is used on normally distributed populations

when the population standard deviation is unknown. Therefore, it assumes the population is normally distributed. To apply the Student t-test and confidence level estimators, the sample standard deviation is substituted for the population standard deviation. The first part of this analysis calculates interval estimates about the point means listed in Table 4.5.

The sample means and their 90% intervals are graphically represented in Figure 4.4:

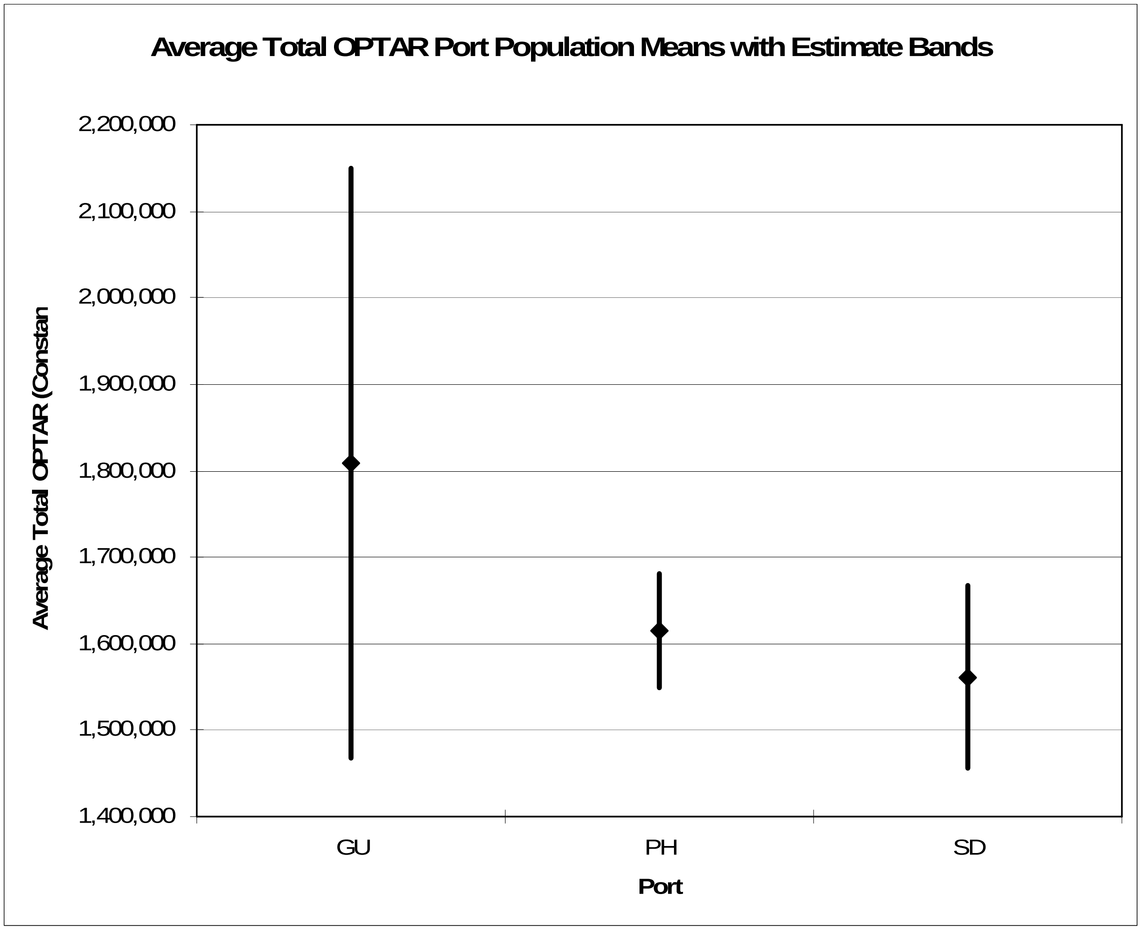

Figure 4.4. Average Total OPTAR by Homeport with 90% Confidence Intervals

The t-estimates of the means provide an interval over which the mean might be located. For example, Figure 4.4 shows the point estimate for Guam is $1.8 million, but with 90% confidence, this mean could actually be as low as $1.47 million or as high as $2.15 million. An important feature to note in Figure 4.4 is the band from

approximately $1.55 million to $1.65 million, where all the intervals overlap. This may indicate the Total OPTAR homeport population means are all equal. To confirm this, the Student t-test was applied to the samples.

In order to apply the Student t-test, the population variances have to be assumed as equal or not equal. Since the true population variances are unknown, the F-test is applied prior to doing the Student t-test. The F-test tests if the population variances are equal or unequal based upon the variances in the samples from the populations. The hypotheses tested with the F-test are:

H_0: Population variances are equal

H_1: Population variances are unequal

The sample variances are in Table 4.5. They are all the same order of magnitude. The variances for Guam and Pearl Harbor are very close, while the San Diego variance is smaller. The results of the F-test are displayed in Table 4.6.

Total OPTAR	
F-test for Population Variances	
Populations Compared	P (one-tail)
GU to PH	0.4353
GU to SD	0.3174
PH to SD	0.2132

Table 4.6. Results of F-test for Total OPTAR homeport populations

Since the p-values for the F-test are greater than the standard p-values of 0.1, 0.05 and 0.01, there is not enough evidence to reject the null hypothesis at any significance level. Therefore the variances for the three different Total OPTAR populations are equal. The Student t-test assuming equal population variances is now applied to the three samples.

The "Two Sample t-test Assuming Equal Variances" function was used in Microsoft Excel. The hypotheses were:

H_0: Mean (Pearl Harbor) = Mean (San Diego)

H_1: Mean (Pearl Harbor) $\neq$ Mean (San Diego)

This tests the assumption that the average yearly Total OPTAR spending for each of the ports is equal. The output from Excel's Student-t test function is in Table 4.7:

Parameter	Value
t Statistic	0.6904
P value – one tail test	0.2453
P value – two tail test	0.4906

Table 4.7. Student-t test on Samples from PH and SD, Total OPTAR, assuming equal variances

The calculated p-values of 0.2453 and 0.4906 are greater than the standard alphas. There is not enough evidence to reject the null hypothesis at any confidence level. The population means are equal.

Hypothesis testing was performed between Guam and Pearl Harbor and Guam and San Diego. These tests were used to compare the population means between the Total OPTAR homeport populations. These tested the general null hypothesis:

$$H_0\text{: Mean (Port 1)} = \text{Mean (Port 2)}$$

$$H_1\text{: Mean (Port 1)} \neq \text{Mean (Port 2)}$$

The complete results of the hypothesis testing for the Total OPTAR homeport populations are in Table 4.8:

Total OPTAR Homeport Populations		
t-Test of Population Means		
Ho: Mean Port 1 = Mean Port 2		
H1: Mean Port 1 is not equal to Mean Port2		
Populations Compared	P (one-tail)	P (two-tail)
GU to PH	0.1523	0.3047
GU to SD	0.0888	0.1776
PH to SD	0.2453	0.4906

Table 4.8. Total OPTAR Homeport hypothesis testing

The two-tail p-values support the null hypotheses. The population means are not statistically different at any confidence level. The one case that would reject a null hypothesis is a one-tail test between the Guam and San Diego populations at the 90%

confidence level. If Guam boats were suspected to spend more Total OPTAR than San Diego boats, the null hypothesis would be rejected in favor of the alternate hypothesis. In that case, one could conclude (with 90% confidence) the mean for the Guam Total OPTAR population was greater than the mean for the San Diego population.

Testing for Repair OPTAR and Other OPTAR was conducted in a similar fashion. These results are presented in the following two sections.

b. Repair OPTAR Port Populations

For this case, similar to the analysis done on the Total OPTAR port populations, the Repair OPTAR sample is divided into the three respective ports. For the application of the t-estimate of the mean and the Student t-test the Repair OPTAR port samples are considered small samples of their larger population. In this case, the larger population is the population of all yearly Repair OPTAR expenditures for one particular port. This gives three distinct populations to compare. These are referred to as the Pearl Harbor Repair OPTAR population, the San Diego Repair OPTAR population and the Guam Repair OPTAR population. The sample statistics associated with these samples are in Table 4.18:

	PH Repair OPTAR Sample	SD Repair OPTAR Sample	GU Repair OPTAR Sample
Statistic	Statistic Value (FY’06 $)	Statistic Value (FY’06 $)	Statistic Value (FY’06 $)
Number of Observations	187	64	9
Mean	1,300,986	1,282,234	1,589,722
Median	1,249,273	1,320,213	1,610,019
Mode	N/A	N/A	N/A
Variance	$2.585*10^{11}$	$2.085*10^{11}$	$2.653*10^{11}$
Standard Deviation	508,444	456,647	515,097
Standard Error	37,181	57,081	171,699

Table 4.9. Repair OPTAR Port Samples (1996-2006)

The Student-t interval estimator is used to provide a confidence interval associated with the point estimates listed in Table 4.9. Figure 4.5 is the graph of these point estimates banded by their 90% confidence intervals.

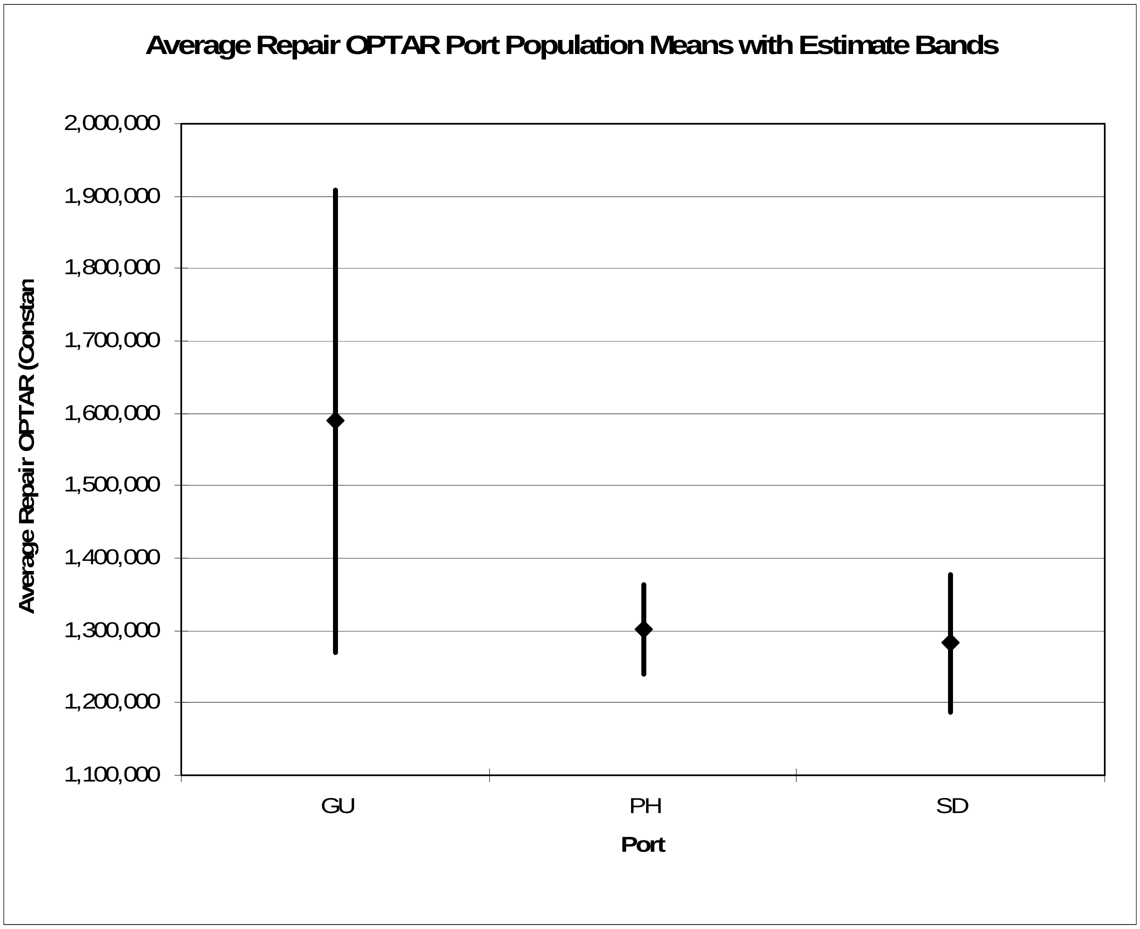

Figure 4.5. Average Repair OPTAR by Homeport with 90% Confidence Intervals

Figure 4.5 looks like Figure 4.4. This is not surprising since Repair OPTAR expenditures make up a large portion of Total OPTAR. Again, with the t-intervals displayed like this, the overlap band is very apparent. Here the population means could overlap between \$1.28 million to \$1.36 million. The question is the same: Are these means different enough to say the samples come from different populations and conclude if one port is more expensive than another?

Student-t analysis was performed in the same fashion as the Total OPTAR population comparisons. First the F test was used to determine if the population variances were equal, then the appropriate Student-t test was used to compare the means.

The hypotheses tested with the F-test were:

H_0: Population variances are equal

H_1: Population variances are unequal

Repair OPTAR	
F-test for Population Variances	
Populations Compared	P (one-tail)
GU to PH	0.4177
GU to SD	0.2740
PH to SD	0.1618

Table 4.10. Results of F-test for Repair OPTAR homeport populations

Table 4.10 shows that for the standard alpha values of 0.1, 0.05 and 0.01, there is no significance. There is not enough evidence to reject the null hypothesis and the population variances are equal.

The Student-t test assuming equal variances was applied. The results are listed in Table 4.11:

Repiar OPTAR Homeport Populations		
t-Test of Population Means		
Ho: Mean Port 1 = Mean Port 2		
H1: Mean Port 1 is not equal to Mean Port 2		
Populations Compared	P (one-tail)	P (two-tail)
GU to PH	0.0489	0.0979
GU to SD	0.0333	0.0666
PH to SD	0.3971	0.7942

Table 4.11. Repair OPTAR Homeport hypothesis testing

These results show some significantly different population means. The Pearl Harbor Repair OPTAR population mean and the San Diego Repair OPTAR population mean are so close they are not significantly different but when Guam is compared to the two, there are significant differences. The two-tailed test results show

the Guam Repair OPTAR mean is different than both the Pearl Harbor and the San Diego mean at the 0.1 significance level. With a 90% confidence, one can say the Guam Repair OPTAR population is different from the other two. Using the one-tailed result the difference is significant at the 0.05 significance level. The one-tailed results would be used if the test was directional. If the alternate hypothesis stated the Guam Repair OPTAR population mean was greater than the other two population means, the one-tailed results allow rejection of the null hypothesis with a 95% confidence level. The alternate hypothesis is accepted and the Guam Repair OPTAR population is greater than the Repair OPTAR populations of the other two ports.

c. Other OPTAR Port Populations

Analysis proceeds in a similar fashion as the previous two sections. Table 4.12 presents the pertinent facts regarding the sample statistics:

	PH Other OPTAR Sample	SD Other OPTAR Sample	GU Other OPTAR Sample
Statistic	Statistic Value (FY'06 $)	Statistic Value (FY'06 $)	Statistic Value (FY'06 $)
Number of Observations	187	64	9
Mean	314,458	279,435	218,554
Median	281,729	283,327	213,657
Mode	N/A	N/A	N/A
Variance	$1.939*10^{10}$	$8.648*10^{9}$	$2.674*10^{9}$
Standard Deviation	139,263	92,996	51,713
Standard Error	10,184	11,625	17,238

Table 4.12. Other OPTAR Port Samples (1996-2006)

Figure 4.6 shows the population point estimates from Table 4.12 and bands them with the 90% confidence intervals calculated by the Student t-test. Graphically, there is a lot of difference between the point means for each port. Additionally, there is very little overlap at the 90% confidence level. If the 95% or 99% confidence levels were graphed, the band would increase and more overlap would appear.

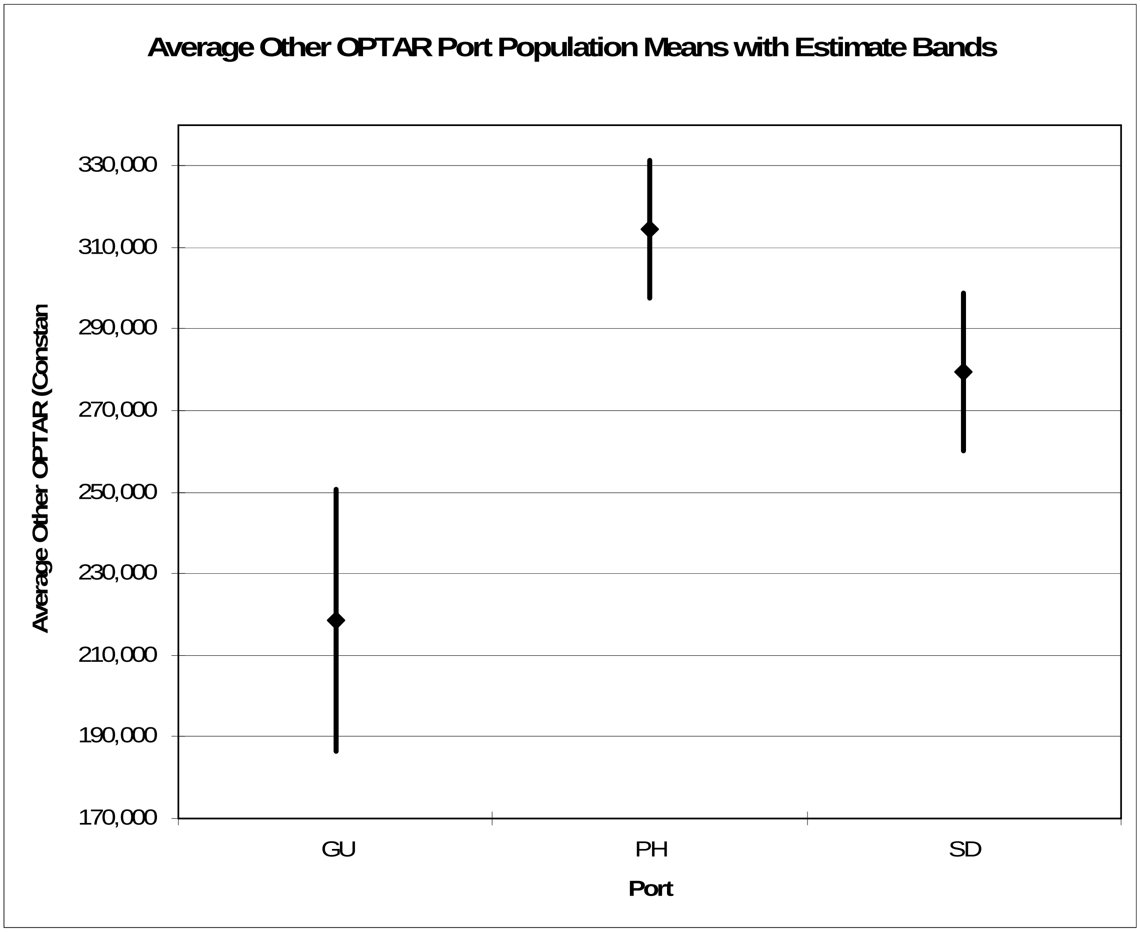

Figure 4.6. Average Other OPTAR by Homeport with 90% Confidence Intervals

The results of the F-test are in Table 4.13. The null and alternate hypotheses are the same as in the two previous sections:

Other OPTAR	
F-test for Population Variances	
Populations Compared	P (one-tail)
GU to PH	0.0026
GU to SD	0.0402
PH to SD	0.0002

Table 4.13. Results of F-test for Other OPTAR homeport populations

These results show the null hypothesis should be rejected in favor of the alternate. While the variances for the Guam and San Diego populations are within the same order of magnitude, they are still different enough to conclude the populations have

different variances. Inspecting Table 4.13 allows acceptance of the alternate hypothesis and rejection of the null. The variances are not equal.

The Student-t test is now applied assuming unequal variances. The results of this hypothesis test are displayed in Table 4.14:

Other OPTAR Homeport Populations		
t-Test of Population Means		
Ho: Mean Port 1 = Mean Port 2		
H1: Mean Port 1 is not equal to Mean Port 2		
Populations Compared	P (one-tail)	P (two-tail)
GU to PH	0.0001	0.0003
GU to SD	0.0049	0.0098
PH to SD	0.0124	0.0247

Table 4.14. Other OPTAR Homeport hypothesis testing

Analyzing the two-tailed results in Table 4.14 at the 95% confidence level, the null hypothesis is rejected in all cases and the alternate is accepted. This infers the population means are not equal. If the tests were directional, and the alternate hypothesis stated one of the populations was greater than the other, than all the results would be significant at the 99% level.

d. Summary of OPTAR Port Population Results

A summary table is provided to present the result of the port population hypothesis testing:

Summary Table of P-values:						
	Total OPTAR		Repair OPTAR		Other OPTAR	
Populations Compared	One-tail	Two-Tail	One-tail	Two-Tail	One-tail	Two-Tail
GU to PH	0.1523	0.3047	**0.0489**	**0.0979**	**0.0001**	**0.0003**
GU to SD	**0.0888**	0.1776	**0.0333**	**0.0666**	**0.0049**	**0.0098**
PH to SD	0.2453	0.4906	0.3971	0.7942	**0.0124**	**0.0247**

Table 4.15. Student t-Test Hypothesis test results

Table 4.15 lists the significant results in bold. Looking at the Total OPTAR population hypothesis results, the one tailed test between Guam and San Diego is significant. For the Repair OPTAR population the Guam population is different than

either the San Diego population or the Pearl Harbor population. Finally, the Other OPTAR populations are all different when compared to each other.

The use of the Student-t test requires some underlying assumptions which are critical to its application. If these assumptions do not apply to the population, the Student-t test may not provide accurate results.

First, the Student-t test assumes the data set is modeled by the normal distribution. If the population data are not normally distributed the Student-t test will not provide accurate results. The second assumption is that the data set is composed of random, independent events. This assumption, when applied to these data, means the matching of expenditures to ships is completely independent from the previous year's spending levels. If the expenditure data points were truly independent events this would mean each year's expenditure totals would be randomly assigned to each unit from the population in question. The assumption of random and independent may not hold up if there is a year-to-year dependence or if particular boats are simply always more expensive than others. Further analysis would have to be conducted to determine if this was true. One final problem with the Student-t test is that it compares the sample means. This means the test is more sensitive to outliers. The Wilcoxon rank-sum test is not influenced by outliers, since it only looks at the order of the observations and not the statistics calculated from those observations.

B. WILCOXON RANK-SUM TEST

In an attempt to overcome some of the problems presented by the t-test, the Wilcoxon rank-sum test was performed on the data.

The Wilcoxon rank sum test is a non parametric test. Non-parametric tests were developed to be used when the researcher doesn't know the parameters of the underlying distribution of the variable of interest in the population (Statsoft.com, 17APR07).[21] The Student t-Test assumes the populations are normally distributed. If the data do not follow the normal distribution Student's test may not provide accurate results. For the rank-sum

[21] Statsoft.com, accessed 17APR07.

test, the data set does not need to be normally distributed. The Wilcoxon test doesn't look at the data values or frequency of occurrence, only at how the data ranks with respect to each other. Instead of comparing population means, as in the Student t-Test, the Wilcoxon rank-sum test compares the difference in population locations.[22]

The Wilcoxon test provides results similar to the Student-t test. The results provide evidence showing if the two samples came from the same population or different populations.

The Wilcoxon test was applied in two different ways. First, the test was applied on yearly OPTAR data. This was done in an attempt to correct the potential problem of year-to-year data dependency. By sampling by year, we also would eliminate any dependency upon a high yearly spending. For example, if spending was unusually high in one year for all fleet units, this would skew the aggregate level of analysis.

The Wilcoxon rank-sum test was also applied in an analogous way as the Student-t Test. Port samples were compared within the three main populations of Total OPTAR, Repair OPTAR and Other OPTAR. This was done as a non-parametric backup to the parametric Student-t Test.

In the following section, the test is described using an example from the 1996 Total OPTAR expenditure data. The method followed is taken from Sheldon M. Ross's Introductory Statistics textbook.[23]

1. Yearly Sample Example of the Wilcoxon Rank-Sum Test

The 1996 Total OPTAR spending data will be used to briefly describe the major aspects of the Wilcoxon test. In 1996 there were 21 boats in the Pacific Fleet. San Diego was the homeport for eight of these boats and Pearl Harbor had the rest.

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[22] Keller, 726.

[23] Sheldon M. Ross, Introductory Statistics (Burlington, MA: Elsevier Academic Press, 2005), 651-653.

Like the Student-t test, this test determines if the samples came from the same population or if they came from different populations. As the hypotheses indicate, this is a two-tailed test:[24]

H_0: Population Distribution San Diego = Population Distribution Pearl Harbor

H_1: Population Distribution San Diego $\neq$ Population Distribution Pearl Harbor

If the null hypothesis is true and the samples came from the same population distribution, the rank-sum test statistic would be close to the expected rank sum for the sample size. If the samples came from different distributions, the test statistic would be significantly smaller or larger than the average rank sum for the sample size in which case the null hypothesis would be rejected. A small test statistic would indicate the sample came from a population that had lower values. In other words, a significantly small test statistic indicates the sampled population distribution is shifted to the left of the other population distribution. Likewise, a high value for the test statistic indicates the sampled population distribution is shifted to the right of the other distribution. The test statistic is taken to the Wilcoxon tables and p-values are calculated and compared to the standard significance levels.[25]

The first step to apply the Wilcoxon test is to rank the dependant variable in ascending order. The sample identities must be maintained with the data values. Table 4.15 presents this for the 1996 Total OPTAR spending values:

[24] Ross, 652.

[25] Ibid., 653.

Ship Homeport	Total OPTAR (Constant FY 06$)	RANK
PH	836497	1
PH	867027	2
PH	1048904	3
PH	1177382	4
SD	1190922	5
PH	1210168	6
SD	1220513	7
PH	1284125	8
PH	1421130	9
SD	1422335	10
SD	1456595	11
PH	1537114	12
SD	1556567	13
PH	1587582	14
PH	1666676	15
SD	1694847	16
PH	1712870	17
SD	1715321	18
PH	1778207	19
SD	1819881	20
PH	1941916	21

Table 4.16. 1996 Total OPTAR, database output, Ranked

From this table, the rank sum test statistic and the expected rank sum are calculated. The "rank-sum" is computed using the San Diego sample. To create the San Diego "rank-sum," the rank values assigned to each San Diego datum point are added together. In this example, the rank-sum is 100 (5+7+10+11+13+16+18+20). The expected rank-sum is the average rank sum based upon the total number of observations and the sample size. (The equation for the expected rank sum can be found in Ross, page 653.) The expected rank-sum value for this sample is 72.

Using the actual rank-sum, the expected rank-sum, the rank-sum variance and statistical tables, The Wilcoxon test provides a p-value for the hypothesis test.[26] Specifics of the Wilcoxon test can be found in the Ross textbook. Ultimately, STATA 9 (a statistical analysis program) was used to perform the Wilcoxon test on each of the yearly samples.

[26] Ross, 653.

For this example, the p-value was 0.3848. This means that if the null hypothesis is true, there is a probability of 38.48 percent that the rank sum is as far away from 72 (the expected rank sum) as 100 (the test statistic.) In other words, the rank-sum for the San Diego sample (100) was not significantly greater than the expected average rank sum of 72. There is not enough separation between these two values to say with any confidence the San Diego sample and the Pearl Harbor samples come from different populations. There is not enough evidence to reject the null hypothesis at the 90% confidence level.

This test was repeated from 1996 through 2006 for the three categories of Total OPTAR, Repair OPTAR and Other OPTAR. Since Guam was opened as a homeport starting in 2003, the three years from 2004 to 2006 were treated differently than the previous years where only two ports were sampled. (Guam only had one boat in 2003 so the Wilcoxon rank sum test for that year was not calculated.) For the years from 2004 to 2006, the rank-sum test was applied three times, once between each pair of port combinations.

The complete Wilcoxon results are summarized in Appendix C. The analysis of these results follows.

From the Wilcoxon year-by-year results, there is no statistically significant indication that one port is more expensive than another. Appendix C Part A displays the OPTAR comparisons of Pearl Harbor and San Diego. For Total OPTAR, significant differences were found in FY 2000, 2001 and 2003 but the population shift is different between the three years. The FY 2000 sample shows San Diego more expensive than Pearl Harbor, while the samples from FY’s 2001 and 2003 show San Diego less expensive than Pearl Harbor. These Total OPTAR differences mirror the components that make them up. The Repair OPTAR samples show San Diego Repair OPTAR spending is significantly higher than Pearl Harbor in 1998 and 2000 while it is significantly less than Pearl Harbor in 2001. Finally, for Other OPTAR, San Diego is significantly less than Pearl Harbor in 2001 and 2003.

These results do confirm that Total OPTAR follows the trends of its parts. For example, in FY 2000, when San Diego Repair OPTAR was more than Pearl Harbor, the San Diego's Total OPTAR was also higher. Similar trends were seen in 2001 and 2003, where San Diego's Other OPTAR and Total OPTAR expenditures were less than Pearl Harbor's.

This test is inconclusive in proving that one port is always more expensive than another. One port is not consistently more expensive than the other with any statistical significance. In fact, within the non-significant years, Pearl Harbor and San Diego trade off as the more expensive or less expensive port several times throughout the data set. Application of the Wilcoxon test in this manner does not show a consistent trend of one port being more expensive than another. Additionally, the years that *are* statistically significant seem to be sporadically spread throughout the data set.

For the Guam comparisons, FY 2004 was the only year with significant results. In the Total OPTAR and Repair OPTAR categories, the boats with Guam as their homeport spent more than both Pearl Harbor and San Diego units.

The sample comparisons between Guam and Pearl Harbor or Guam and San Diego are also inconclusive. These ports also switch from year to year as to which one is more expensive and which one is less expensive.

This test does have some benefits. First, it highlights a few years that may warrant further investigation. In 2001 and 2003, San Diego was less expensive than Pearl Harbor in all spending categories. Deeper investigation could be performed on these years to attempt to explain why this was the case. Comparisons could be drawn between two years that indicate different shifts. These cases could be analyzed to see why the spending difference was so dramatic.

The conclusion of the Wilcoxon test is that there is no significant difference in spending between ports. If the distributions of OPTAR expenditures of each homeport were significantly different or shifted far enough apart than the rank sum of one port

would be significantly higher or lower than the average expected rank sum. Looking at all eleven years of data, and between the three spending categories, no one port dominates the other.

2. Aggregate Port Samples of the Wilcoxon Rank-Sum Test

Next the Wilcoxon rank-sum test was applied to the population samples in a similar fashion as the Student-t test. Similar as before, the three main spending categories were Total OPTAR, Repair OPTAR and Other OPTAR. For this analysis there were three populations in each category. For example, the Total OPTAR category had populations of: Pearl Harbor Total OPTAR, San Diego Total OPTAR and Guam Total OPTAR. The sample for each population consisted of all the data points associated with that category for that homeport.

The Wilcoxon test compares two of samples and tests to see if they came from the same population. If the samples came from the same population, the rank-sum of the sample should be close to the expected rank-sum based upon both sample sizes. If they are significantly different, the Wilcoxon test provides a low p-value signifying a low probability the samples are different due to chance, and pointing toward conclusion the samples come from truly different populations.

Section D of Appendix C presents the Wilcoxon test applied in an equivalent fashion as the Student-t test. The results that are statistically significant are in the Repair OPTAR and Other OPTAR categories. The Repair OPTAR category test showed a significant difference between the Guam and San Diego populations. The indication is that Guam spends more on Repair OPTAR than San Diego.

The Other OPTAR category had significant differences between the Guam and Pearl Harbor populations and the Guam and San Diego populations. In both cases, Other OPTAR expenses were less in Guam than the other ports.

Looking at the non-statistically significant results, there are some comparisons that are almost significant. Tests become more and more significant as the p-value decreases. With a p-value of 0.1091, the Total OPTAR comparison between San Diego and Guam is almost significant at the 90% level.

These results support the Student-t results. The Wilcoxon test shows significance in the same population comparisons as the Student-t test, but the Student-t test had a greater number of significant test results. The Wilcoxon test also supports these other significant tests by having lower p-values for these other comparisons. In these cases, the Wilcoxon results were not statistically significant but they provided p-values of 0.1091, 0.2294 and 0.2312, which, when supported by the accompanying Student-t test results, could be used to show a difference in the population means.

Which one to use, Student-t or Wilcoxon? Each of these statistical methods has its strengths and weaknesses. First off, with the aggregate results, year to year influences are ignored. Boats that might always be more expensive than others are also not accounted for. If a boat is always more expensive than the other boats, and this particular boat is always based out of one port, that single port average will tend to be more expensive when compared to the other ports. This effect will be more apparent in the Student-t test.

The Student-t test assumes a normal distribution. In this analysis, normality was assumed by saying the samples looked “close to normal” and were not “drastically non-normal.” The Student-t test focuses on the population parameters, which are unknown and estimated by the sample statistics. Should an analyst reject any of these assumptions, they could turn to a non-parametric alternative.

In this case, the non-parametric test was the Wilcoxon. The Wilcoxon does not require assumptions regarding the type of distribution. It doesn’t focus on the measurable parameters, but instead tests to see if the populations are shifted between each other. It is also more robust in the presence of outliers. Outliers could certainly occur in a data set comprised of expenditure data.

So depending on how one interprets the histograms of the data, and how one perceives the data to behave, either analysis should suffice. In this case, since both of the tests came the same conclusion, they support each other.

The conclusion from the combination of the Student-t and the Wilcoxon tests is that there are significant differences in Other OPTAR. With respect to the Other OPTAR category, Pearl Harbor spends the most, followed by San Diego and then Guam. The second conclusion is that within the Repair OPTAR category, Guam spends more than San Diego or Pearl Harbor. These conclusions are supported by both statistical tests.

C. REGRESSION WITH PANEL DATA

In an effort to overcome the problems encountered with the Student and Wilcoxon tests, a third statistical analysis was performed. Regression with panel data is an analysis especially developed for data where the same individual (in this case the same ship) is observed multiple times. In this analysis, each submarine is considered an “entity” and they are observed over the course of eleven fiscal years. The eleven fiscal year observations are the time-series aspect of the panel, while the “members” of the panel are the individual boats. Panel data regression is appropriate for the OPTAR data because it can take into account serial correlation in the errors across time for each individual ship.[27]

The dependant variables were Total OPTAR, Repair OPTAR and Other OPTAR. The regression has to be run three separate times, once for each dependant variable.

For the initial panel regression, the only independent variables were the ship’s homeports. A typical observation for a panel member had the associated spending quantity and the homeport. (For example, the SSN-688’s Repair OPTAR observation for Fiscal Year 1996 had a dependent variable value of $1.392M (FY2006) and an independent variable value of Pearl Harbor.)

[27] James Stock and Mark Watson, Introduction to Econometrics (USA: Pearson Education, Inc., 2003), 271.

The collected data amounted to an unbalanced panel. An unbalanced panel is a panel that has missing data for at least one time period for at least one entity (Stock, 272). To highlight an example in this data set, the *La Jolla* (SSN 701) spent FY 1998, FY 1999 and part of FY 2000 in an Atlantic Fleet shipyard, undergoing a refueling overhaul. These years did not reflect spending from an operational Pacific Fleet homeported submarine, so they were dropped from the data set. Since the other years of observations were included (FY 1996, 97 and FY 2001-FY2006) the panel regression would be considered an unbalanced panel.

Panel regression looks at the differences in the dependant variables over time. Multiple independent variables can be included if there are available data. Panel regression will reveal if there are omitted variables that are causing data variations. For this analysis, panel regression with "random effects" was used.[28]

Two useful results can be expected from panel data regression. The first is the data trend and identification of the significant independent variables that influence the dependent variable. The second result is a forecast for future values.

STATA 9 was used to perform the regression. This regression was performed several times, with different independent variable sets. Presented first are the results of homeport data only. The section following that presents the results when schedule data is incorporated into the regression.

1. Regression with Panel Data (Homeport Data Only)

In STATA 9, panel regression was done on the log function of the dependant variables. The independent variables were the homeport indicators and the time indicators. The dependant variables are listed in the left hand column of Table 4.17:

[28] "Random effects" allows STATA to provide the most flexible solution when calculating the regression. More information regarding random effects is on the Internet at "DSS Princeton," an information site about STATA. The full website URL is in the List of References.

Expenditure category (dependant variable)	Homeport (indpdnt var.)	Coefficient (Relative to Guam Expenditures in Percentage)	P-Value
Log(Total OPTAR)	Pearl Harbor	-0.1089	0.456
	San Diego	-0.1893	0.214
Log(Repair OPTAR)	Pearl Harbor	-0.1523	0.396
	San Diego	-0.2342	0.211
Log(Other OPTAR)	Pearl Harbor	0.0529	0.665
	San Diego	-0.0784	0.538

Table 4.17. Regression with Panel Data (Homeports only)

Regression provides coefficients for a regression equation. In this case, the equation is not important but the values of these coefficients *are* important because they define the spending relationships between ports. Guam is the reference port, so the coefficients are expressed in reference to Guam. Since log values were used for regression, the coefficients are a *percentage* of the Guam spending. The regression results for the Log(Total OPTAR) rows in Table 4.16 are interpreted in the following manner: The average total OPTAR cost of ships from Pearl Harbor is 10.89% lower than the average Total OPTAR of ships from Guam. Likewise, the average cost of boats out of San Diego is 18.93% lower than the average Total OPTAR of boats from Guam.

The rest of the table is interpreted in a similar fashion. First, note, none of these results are statistically significant at the normal levels of significance. They all have high p-values, indicating that the percent differences in Table 4.17 are due to sampling errors and are statistically insignificant across the three homeports. More precise p-values may be obtained by increasing the sample size.

The regression results for Total and Repair OPTAR, are similar to the results obtained from the Student analysis showing Guam as the most expensive port for these categories. The Other OPTAR regression also supports the Student test by showing Pearl

Harbor as the most expensive port for Other OPTAR. The regression shows San Diego as the least expensive port for Other OPTAR which is in contrast to the Student results.

Again, these results are not statistically significant. The conclusion drawn from this run of regression data is that there are different variables that correlate to the expenditure levels for Pacific Fleet Submarines.

2. Panel Data Regression With Schedule Data

STATA was used for this analysis. The dependant variables were the Log function values of Total, Repair and Other OPTAR, (see Table 14.18) For this analysis, the independent variables were Days Underway and Days Underway Deployed. Table 14.18 shows these results.

Expenditure category (dependant variable)	Coefficient for Days Underway (% OPTAR increase)	P-Value	Coefficient Modifier for Days U/W Deployed	P-Value	Coefficient for Days U/W Deployed (% OPTAR increase)
Log(Total OPTAR)	0.00284	0.0	-0.00137	0.0	0.00147
Log(Repair OPTAR)	0.00339	0.0	-0.00177	0.0	0.00162
Log(Other OPTAR)	0.00135	0.0	-0.00018	0.503	- -

Table 4.18. Regression with Panel Data (Days Underway)

The interpretation of this analysis is slightly different than the previous panel data interpretation. Here, the coefficients are “marginal modifiers.” As such, they adjust their associated expenditures based upon the increase or decrease of their associated independent variables.

For example, in the second column of the Total OPTAR row, the coefficient associated with “Days Underway” is 0.00284. For the nominal boat with average characteristics (i.e., an average amount spent on Total OPTAR and an average number of days spent at sea) its Total OPTAR expenditures will be 0.284% higher if it spends one

more day at sea in a non-deployed status. From the fourth and sixth columns, if that additional day underway is in a deployed status, the Total OPTAR expenditures will be 0.147% higher (0.284% - 0.137%).

Another example using numbers is helpful. Assume the "average boat" spends 120 days underway and spends $1.3M (FY 2006) on Repair OPTAR. If the boat must be underway in a non-deployed status for 1 day over the average, the Repair OPTAR will increase by 0.339%. If the boat will spend an additional 30 days underway, Repair OPTAR will increase by 10.17% (0.00339 * 30 days). This will increase Repair OPTAR by $0.132M for a new Repair OPTAR expenditure of $1.43M. The same logic can be applied to the deployed modifiers.

All of the results with schedule data as an independent variable are significant except for the deployed status under the Other OPTAR category. This is probably due to the nature of the Other OPTAR expenditures. They would depend mainly upon the days underway and the days in port. Delineation between the two underway statuses does not affect the Other OPTAR expenditures. Therefore, there is no additional modification for Other OPTAR if additional days are spent underway and deployed.

3. Panel Data Regression Summary

These results show OPTAR expenditures are highly dependent upon schedule. The regression with panel data including homeports but no schedule data did not reveal significant differences between locations. In this case, the panel regression stated there were other independent variables driving the OPTAR costs. The second regression included the schedule data. This showed significant results based upon days underway. Additional granularity was achieved by breaking the days underway into local operations and deployed operations. The boats pay more for local operations than for deployed operations.

D. ANALYSIS SUMMARY

This chapter opened by looking at top level data and provided statistics on the sampled expenditure data. Next, it broke the three OPTAR categories into 9 different

populations designated by OPTAR category and location. The Student-T test was performed on these populations to see if their means differed. The Wilcoxon rank-sum test was applied to these populations to see if their distributions were shifted from each other. The Wilcoxon test was applied from year to year to see if an additional analysis would show consistent differences. Finally, regression with panel data was used to look at the influence of homeport data and the influence of schedule data.

Depending upon the assumptions of the analyst and the observed nature of the data, any of the above analyses may be accepted or rejected. The student-t test showed homeport differences in Repair OPTAR and Other OPTAR. Wilcoxon applied from year to year was inconclusive. Wilcoxon applied as a back up to the Student test supported the results of the Student test.

Finally, regression by homeport data had no statistically significant results. Regression with schedule data included as an independent variable, though, did reveal strong correlations between deployed days and OPTAR expenditures.

The Student-t and Wilcoxon test showed significant differences in the Other OPTAR category. The next chapter will briefly present the Cost Element Structure of the Other OPTAR categories.

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V. OTHER OPTAR COST ELEMENT STRUCTURES

This chapter presents the Cost Element Structure (CES) of the Other OPTAR spending category for each homeport. Cost element structures are tools used by cost estimators to break an Operating and Support total cost component into its various parts. It is analogous to a work breakdown schedule but it only applies to the Operating and Support Costs of a weapon system.

Since the Student test and the Wilcoxon test showed significant differences in the Other OPTAR category between homeports, it is helpful to look at this category and see how much each of the seven different pieces contribute. Large differences in the CES between homeports point at areas that may require further investigation.

This analysis was done in two parts. There is a top level analysis which presents the CES at the aggregate level. The top level chosen for this was the averages at the homeport level. The second tier of this analysis broke out the averages by year and homeport. All of the tables and graphs for this section are displayed in Appendix D.

A. OTHER OPTAR BREAKOUT: AGGREGATE LEVEL

The top level was calculated by taking the three populations defined by homeport (Other OPTAR Pearl Harbor, Other OPTAR San Diego, etc.) and taking the average of each of the seven areas that make up the populations. The averages were calculated using all the observations for that port, making this the "aggregate level." All the data points available for each port were used to calculate the average from each port. Table D.1 (Appendix D, Section A) lists the results of these calculations.

The results in Table D.1 give the CES for the typical (or average) boat from a single port. The results show the highest spending category across all the ports is Consumables. Additionally, units from Pearl Harbor and San Diego spend more in the categories of ADP Rentals/Contracts and POL Other than the Guam boats.

The vertical analysis of Table D.1 expresses each of the category spending amounts as a percentage of the total Other OPTAR spending average. This shows the

typical boat in Guam spends 78% of its Other OPTAR budget on the Consumables category. Pearl Harbor and San Diego boats spend 54% and 58% of their budgets on Consumables, respectively. Two areas in the Pearl Harbor and San Diego CES receive a higher proportion of the total Other OPTAR funding than Guam. These two areas are ADP Rentals and Contracts, and Equipment.

Knowing and understanding this aggregate analysis could start to identify the cost drivers within the Other OPTAR category. Cost drivers are the specific activities that cause the ships to incur costs. For example, cost drivers associated with the Telephone/Postal category are likely to be such things as the number of phone contracts, frequency of written correspondence and number of mass mailings. The average unit out of Pearl Harbor spends about two times more in this area than a unit from the other two ports. Noting this, one can look into the command practices of the units at Pearl Harbor.

This investigation would help to identify if the cost differences are controllable or if they are uncontrollable. In the case of postal expenses, if the commands in Pearl Harbor spend more on postage because they do more mass mailings, this might be a controllable cost (do fewer mailings). If the number of mailings is the same, but they pay a premium for being OUTCONUS, this cost difference would be considered uncontrollable. This identification of controllable versus uncontrollable costs would be useful for defending spending totals.

Areas that have cost differences and could be investigated further are, Telephone/Postal, ADP Rentals/Contracts, Printing/Copying, TAD, Equipment, Other POL. These are all categories where one or two ports are much more expensive than the others.

B. OTHER OPTAR BREAKOUT: YEARLY LEVEL

The second level of analysis conducted on the Other OPTAR CES breakout was the yearly averages by port. For this calculation, each of the years was considered in isolation. The observations for each port in that year were summed and averaged. This allowed a trend analysis of each port’s Other OPTAR expenditures.

This analysis is presented in Appendix D, sections B, C and D. Table D.2, in section B, shows the averages for each port in each fiscal year. Section C displays graphs of the tables in Section B. Section D is the graphical representation of the vertical analysis of the tables in Section B. (For the vertical analysis, each category's average expenditures were expressed as a percent of the average total Other OPTAR spent by the boats from that port, in that year.)

Figures D.1, D.2 and D.3 (Appendix D, Section C) are useful to help quickly find the highlights of Other OPTAR funding. The most expensive years and the least expensive years are easily identified. The trend over time is also readily apparent.

Analysis of the Pearl Harbor graph (Figure D.1) shows Other OPTAR expenditures have been decreasing since their peaks in 2001 and 2003. Also, in 2004, ADP Rentals/Contracts and Equipment expenses decreased and have stayed down since then.

From the San Diego graph (Figure D.2), San Diego Other OPTAR peaked in 1999 and has been declining ever since. Since 2002, the average expenditures in the ADP Rentals/Contracts category have been decreasing. Spending on consumables has been fairly steady with a slight dip in 2002.

From the Guam graph (Figure D.3), Other OPTAR continues to decrease over time.

Section D of Appendix D, presents graphical versions of the vertical analysis performed on Table D.2. Each individual cost category is expressed as a percent of the total Other OPTAR spent for that year. For Pearl Harbor (Figure D.4), over the past four years, Consumables are taking up more of the Other OPTAR each year. Additionally, the ADP category is taking up less of their total Other OPTAR. In the San Diego graph, Figure D.5, Consumables continue to take up larger percentages of their total Other OPTAR category. Spending on ADP is taking up less of the Other OPTAR spending over time.

This yearly data is valuable to show the years of high and low spending and to point out the spending trends (for the total amount and individual parts of Other OPTAR.)

This method allows quick determination of high spending years and low spending years. These years of interest could be broken down to see how the money was spent and why the amounts were high or low. Comparisons between the various cases might show if improvements in spending are feasible. If not, the analysis could justify the spending totals.

Trends over time could predict future years of spending. Additionally drastic changes in individual categories from year to year might show adoption of cost saving practices or potential problem areas.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. IS THERE A DIFFERENCE IN OPTAR EXPENDITURES BETWEEN HOMEPORTS?

To answer this question, a statistical analysis was performed on unit level expenditure data obtained from VAMOSC. Homeport data were obtained from the SUBPAC UIC responsibility lists.

The analysis focused upon three different populations of OPTAR. The three populations were Total OPTAR, Repair OPTAR and Other OPTAR. (Total OPTAR simply being a sum of Repair OPTAR and Other OPTAR.) In Chapter IV it was shown, on average, Repair OPTAR is 90% of the Total OPTAR.

Three statistical analyses were used to see if the observed differences in OPTAR expenditures between the three Pacific homeports were statistically significant.

Results of the Student-t test showed each location's Other OPTAR populations were significantly different from each other. This was supported by a similar application of the Wilcoxon rank-sum test. Based upon the Student-t and Wilcoxon results, there are significant differences in the Other OPTAR and the Repair OPTAR categories between homeports.

In a final effort to better model the data with another statistical test, regression with panel data was used. This regression analysis showed no significant differences between homeports for any of the three OPTAR populations. This result indicated there was another independent variable that could be used to describe the cost relationship. Regression with panel data was tried again, this time with "total days underway" and "days underway, deployed" as independent variables. This second analysis provided significant coefficients for the independent variables based upon schedule for the Total and Repair OPTAR populations.

Based upon the Student-t and Wilcoxon tests, it is concluded that there are significant differences in Other OPTAR and Repair OPTAR expenditures between homeports. Based upon the regression with panel data, a significant predictor of OPTAR costs is not the unit's homeport location, but the schedule.

B. RECOMMENDATIONS

1. Take a Close Look at the Other OPTAR Spending Category

a. Look for the Drivers of the Geographic Differences

Other OPTAR was proven to have differences by geographic location. One reason why Other OPTAR shows differences by homeport location is that it can take into account cost of living differences. Consider differences in local labor rates. Due to cost of living differences, a contract in San Diego is going to have a different labor rate than a contract in Pearl Harbor or Guam. Each port currently has a different minimum wage at $7.50/hour, $7.25/hour and $5.15/hour for Pearl Harbor, San Diego and Guam, respectively.[29] The implications of this are clear. Contracts from different locations with identical direct labor hours will most likely have different direct labor *rates*. This is an uncontrollable cost that is highly dependant upon location. When budgeting for a particular port, these cost of living and labor rates are real and should be considered when requesting Operating and Support funds.

Repair OPTAR is spent upon items that are used for routine preventative maintenance. By definition, all these items are purchased from the Navy Stock Account. The pricing for these parts is fairly consistent between ships and ports. The difference in Repair OPTAR between Guam and the other ports might be due to higher transportation charges in the Navy Stock Account. This would justify the higher average Repair OPTAR expenses seen in the more distant Guam homeport.

[29] "Minimum Wage Laws in States." www.dol.gov, accessed 11MAY2007.

b. Some Other OPTAR Expenses Appear to Have Discretionary Aspects where Repair OPTAR Have Mandatory Qualities

Which OPTAR costs are "discretionary"? Which are "mandatory"? In this context, discretionary costs are costs that are influenced by the command climate and driven by the "wants" of a command rather than the "needs" of the command. Mandatory costs are costs the command *must* incur.

First, consider that Repair OPTAR goes to purchase parts used for routine preventative maintenance. Preventative maintenance is, for the most part, standardized within a ship class. Units have little control over when and how often to perform it. Because of this, Repair OPTAR should be fairly constant between boats. Taking this factor into account, Repair OPTAR probably acts mostly like a mandatory expense account. Repair OPTAR expenditures should be used to justify large OPTAR spending requests.

Other OPTAR expenditures look more discretionary than Repair OPTAR. An example of one such category is ADP Rental/Contracts. Each command has different information technology needs and plans. One command may call for replacing computer hardware and software more often, which would increase their ADP costs.

Another discretionary cost is the Telephone and Postal costs. As pointed out in Chapter V, postage expenses will vary based upon the amount of correspondence the command initiates. This will act like a discretionary expense.

Classification of expenditures into categories is important to help identify areas where savings could be generated as well as areas which cannot be cut. If Total OPTAR was cut across the board, commands would have to take the money out of the discretionary portions of Other OPTAR. They cannot be flexible with repair parts for required preventative maintenance. The Repair OPTAR will be one of the last things cut.

2. Look to Activity Based Costing (ABC)

OPTAR expenditures are Operating and Support Costs. Many of these costs are going to be directly associated with some type of activity. Activity Based Costing will

link activities to costs. Two benefits arise if the OPTAR amounts can be directly attributed to activities. The first benefit is more accurate OPTAR predictions. The second benefit is OPTAR spending that is easily defendable. By shifting to ABC, budget cuts are translated into lost activity. If a budget cut is expressed in terms of activity rather than dollars, it is easier to justify the required OPTAR amounts. In contrast, it is harder to make cuts when the funding is defended in this way.

3. Ask: Is There a Propensity to Spend What Is Allotted?

This statistical analysis won't tell if one command has a "spend it all" type of mentality while another command has a saving mentality.

The Financial Management Instruction states that September obligations should be 100% in each OPTAR category.[30] This opens the possibility that expenditure amounts may not be dictated by the unit, but may be dictated by the size of the grant provided by the comptroller. If this is the case, than spending totals would not necessarily be "driven" by any sort of normal cost driver but by the ability of the command to spend all their OPTAR. Analysis of spending differences by location would have to take in to account another variable which is **the amount of OPTAR granted**. Strict adherence to this instruction means that units will spend all of their OPTAR every year. If more OPTAR is allotted, then boats will spend more. This factor is budgetary in nature and is not directly related to location or command climate.

If units are to spend only what they need, phrases such as "Spend OPTAR grants to zero" and. "Do not hold any unobligated reserves," should be stricken from the financial management instructions.[31] If OPTAR expenditures are based upon the amount of OPTAR allotted instead of the amount of OPTAR needed, than a ship's activity does not drive the amount of OPTAR spent. Rather, the size of the quarterly OPTAR grant drives the spending levels.

[30] COMSUBLANT/COMSUBPAC INST 7330.5A, 2-35.

[31] Ibid., 2-36.

4. Use VAMOSC for Future OPTAR Research

Use the relationships discovered between the SR and SO OPTAR totals, their respective fund codes and the various VAMOSC funding categories to conduct future OPTAR cost studies. VAMOSC is a convenient, useful and robust database and it has good potential to further other OPTAR research projects.

C. AREAS FOR FURTHER RESEARCH

1. Build Predicative Model Based upon Activity

This is an area of potential research. There are some OPTAR models in use, but not at the SUBPAC level. In order to better predict spending a model based upon various independent factors (homeport, platform, time since overhaul, days underway etc.) could be used to estimate the amount of OPTAR to be granted to each boat each quarter. This model will aid in spending justification and it will help to build operating and support budgets.[32]

2. Identification of Cost Drivers/ABC

This is a logical outreach from this thesis. Now that definitive cost differences have been found between various ports, activities can be looked at to see why one port costs more than another. The key to finding cost drivers is to look for the activities which incur costs. When these activities are known costs can be assigned. This cost driver approach will also link closely to an ABC approach to OPTAR funding.

3. Perform Analysis with "OPTAR Grant" as an Independent Variable

This analysis might reveal the true cost driver of OPTAR expenditures. If every command and every supply officer is trying to spend all of their OPTAR by the end of

[32] Currently a student is drafting a proposal for an NPS thesis project which is attempting to build a model using the Crystal Ball software application and using some of the data analysis methods outlined in this thesis.

the fiscal year, their expenditures will be driven solely upon trying to meet their "Operating Target." Statistical analysis using the size of the grant would reveal if another major cost driver was the amount of OPTAR granted.

APPENDIX A: TABLES THAT CROSS REFERENCE OPTAR FOR REPAIR (SR) TO VAMOSC ELEMENT 1.2.2.1

The following two tables identify the connection between the VAMOSC Ship's database element 1.2.2.1 and the comptroller's Repair OPTAR (SR) costs. The first table contains the values from 2005 with all values in 2005 dollars. The second table is in 2002 dollars.

In almost all cases, the "COMPTROLLER'S COR-SR" column equals the rounded value in the "VAMOSC element 1.2.2.1" column. In the other cases they are within a few thousand dollars. Since the values for 2005 and the values for 2002 are so close, the conclusion is they are the same number.

The reason for the differences may be due to time delayed updates to the comptroller's data set. The comptroller's data set is obtained in October following the fiscal year, and this immediacy may cause late year expenditures to be missed in his final totals. The VAMOSC data collection and database posting is not completed until three months into the following calendar year and it likely accounts for these late fiscal year transactions.

Columns practically identical

COMSUBRON ONE

			COMPTROLLER'S COR	VAMOSC
			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 688	LOS ANGELES	20202	933	935,940
SSN 701	LA JOLLA	20826	1,300	1,300,427
SSN 698	BREMERTON	20882	1,036	1,034,568
SSN 715	BUFFALO	20996	1,130	1,129,548
SSN 766	CHARLOTTE	21763	1,311	1,310,886
SSN 772	GREENEVILLE	21831	1,288	1,288,124

COMSUBRON THREE

			COMPTROLLER	VAMOSC
			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 717	OLYMPIA	21024	1,092	1,091,503
SSN 718	HONOLULU	21025	771	771,264
SSN 721	CHICAGO	21100	1,587	1,578,320
SSN 722	KEY WEST	21101	1,571	1,571,398
SSN 724	LOUISVILLE	21302	1,117	1,117,347
SSN 771	COLUMBIA	21817	1,814	1,813,997

COMSUBRON SEVEN

			COMPTROLLER	VAMOSC
			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 752	PASADENA	21413	2,155	2,154,620
SSN 762	COLUMBUS	21692	724	723,999
SSN 763	SANTA FE	21693	1,758	1,757,521
SSN 770	TUCSON	21816	1,882	1,878,541
SSN 773	CHEYENNE	21832	1,300	1,300,082

COMSUBRON ELEVEN

			COMPTROLLER	VAMOSC
			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 707	PORTSMOUTH	20883	5	4,591
SSN 716	SALT LAKE CITY	21023	1,005	1,004,738
SSN 725	HELENA	21367	2,092	2,088,047
SSN 754	TOPEKA	21463	1,271	1,271,056
SSN 758	ASHVILLE	21466	1,401	1,401,438
SSN 759	JEFFERSON CITY	21605	1,903	1,902,888

COMSUBRON FIFTEEN

			COMPTROLLER	VAMOSC
			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2005)**	**(TY $ 2005)**
SSN 705	CORPUS CHRISTI	20832	1,410	1,410,067
SSN 711	SAN FRANCISCO	20887	1,324	1,323,949
SSN 713	HOUSTON	20994	1,847	1,846,697

Table A.1. Comparison between SR and VAMOSC Element 1.2.2.1 – FY 2005

Columns practically identical

			COMPTROLLER	VAMOSC
COMSUBRON ONE			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2002)**	**(TY $ 2002)**
SSN 688	LOS ANGELES	20202	563	562,644
SSN 701	LA JOLLA	20826	1,119	1,118,650
SSN 715	BUFFALO	20996	853	850,284
SSN 766	CHARLOTTE	21763	746	745,564
SSN 772	GREENEVILLE	21831	848	848,136

			COMPTROLLER	VAMOSC
COMSUBRON THREE			SR	Repair Parts (Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2002)**	**(TY $ 2002)**
SSN 717	OLYMPIA	21024	4,482	4,481,904
SSN 718	HONOLULU	21025	1,172	1,171,669
SSN 721	CHICAGO	21100	918	917,637
SSN 722	KEY WEST	21101	502	502,076
SSN 724	LOUISVILLE	21302	1,175	1,174,889
SSN 758	ASHVILLE	21466	324	323,897
SSN 771	COLUMBIA	21817	1,586	1,572,111

				Repair Parts
COMSUBRON SEVEN			SR	(Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2002)**	**(TY $ 2002)**
SSN 752	PASADENA	21413	860	859,912
SSN 754	TOPEKA	21463	618	618,042
SSN 762	COLUMBUS	21692	1,117	1,109,621
SSN 763	SANTA FE	21693	777	776,843
SSN 770	TUCSON	21816	1,074	1,076,193
SSN 773	CHEYENNE	21832	1,383	1,382,661

				Repair Parts
COMSUBRON ELEVEN			SR	(Element 1.2.2.1)
HULL NO.	**NAME**	**UIC**	**(1,000's TY $ 2002)**	**(TY $ 2002)**
SSN 698	BREMERTON	20882	547	546,967
SSN 707	PORTSMOUTH	20883	866	866,177
SSN 713	HOUSTON	20994	196	196,488
SSN 716	SALT LAKE CITY	21023	1,224	1,224,001
SSN 725	HELENA	21367	632	631,617
SSN 759	JEFFERSON CITY	21605	1,336	1,335,710

Table A.2. Comparison between SR and VAMOSC Element 1.2.2.1 – FY 2002

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APPENDIX B: TABLES THAT CROSS REFERENCE OPTAR OTHER (SO) TO VAMOSC

A. OPTAR OTHER (SO) TOTAL TO VAMOSC SUB-CATEGORY TOTAL:

These are the five cases used to establish the relationship between the OPTAR other total and the sum of the applicable VAMOSC sub-elements.

The column under the ship's name and hull number provides the applicable VAMOSC sub-element number and name. Each yearly column lists the "Then Year Dollar" values provided by VAMOSC in each of those spending categories. The bottom two rows of each table provide the totals. The second row from the bottom is the total of the seven rows above it. The bottom row is the SO data provided by the comptroller for that year. The comptroller data are in "Then Year Dollars."

The conclusion is that the VAMOSC sub-element total equals the comptroller's OPTAR Other total. With very few exceptions, a comparison of the bottom two rows of each table shows the rounded total of the VAMOSC sub-elements is equal to the SO data provided by the comptroller. Differences may be due to time delayed updates to the comptroller's data set. The comptroller's data set is obtained in October following the fiscal year, and this immediacy may cause late year expenditures to be missed in his final totals. The VAMOSC data collection and database posting is not completed until three months into the following calendar year and it likely accounts for these late fiscal year transactions.

Los Angeles: SSN 688	2002	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	25,135	15,401	10,419	3,515	
1.2.3.1 Equipment	20,378	67,577	19,779	29,491	
1.2.3.2 Consumables	109,133	191,909	156,811	155,744	
1.3.1 Printing & Copying Services	18,000	12,287	4,504	5,000	Provided by VAMOSC
1.3.2 ADP Rental & Contract Services	4,631	28,179	24,819	18,494	
1.3.4 Telephone & Postal Services	11,730	10,544	24,188	8,867	
1.1.3 TAD	12,889	17,606	16,981	19,387	
Total of VAMOSC provided data:	201,896	343,503	257,501	240,498	Total from VAMOSC
OPTAR other (SO)	202,000	350,000	259,000	241,000	Provided by Comptroller

Corpus Christi: SSN 705	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	45	0	8,551	
1.2.3.1 Equipment	21,637	24,627	26,483	
1.2.3.2 Consumables	152,133	199,892	141,890	
1.3.1 Printing & Copying Services	0	13,402	7,415	Provided by VAMOSC
1.3.2 ADP Rental & Contract Services	35,823	5,991	2,947	
1.3.4 Telephone & Postal Services	16,492	7,250	8,367	
1.1.3 TAD	1,834	0	444	
Total of VAMOSC provided data:	227,964	251,162	196,097	Total from VAMOSC
OPTAR other (SO)	228,000	251,000	196,000	Provided by Comptroller

Chicago: SSN 721	2002	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	8,327	7,676	3,415	5,564	
1.2.3.1 Equipment	10,686	41,180	11,551	5,796	
1.2.3.2 Consumables	117,012	184,558	183,082	172,454	
1.3.1 Printing & Copying Services	18,539	12,896	13,459	4,781	Provided by VAMOSC
1.3.2 ADP Rental & Contract Services	18,252	34,739	11,431	10,969	
1.3.4 Telephone & Postal Services	4,444	8,531	15,709	11,068	
1.1.3 TAD	5,602	12,944	14,500	4,609	
Total of VAMOSC provided data:	182,862	302,524	253,147	215,241	Total from VAMOSC
OPTAR other (SO)	183,000	303,000	253,000	215,000	Provided by Comptroller

Jefferson City: SSN 759	2002	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	10,264	6,972	3,102	8,906	
1.2.3.1 Equipment	8,296	4,811	16,391	9,526	
1.2.3.2 Consumables	92,319	90,498	82,460	220,495	
1.3.1 Printing & Copying Services	5,920	3,543	4,999	0	Provided by VAMOSC
1.3.2 ADP Rental & Contract Services	122,725	20,197	12,981	18,785	
1.3.4 Telephone & Postal Services	12,975	635	0	0	
1.1.3 TAD	17,309	0	0	0	
Total of VAMOSC provided data:	269,808	126,656	119,933	257,712	Total from VAMOSC
OPTAR other (SO)	270,000	127,000	120,000	258,000	Provided by Comptroller

Cheyenne: SSN 773	2002	2003	2004	2005	
	Then Year Dollars	Then Year Dollars	Then Year Dollars	Then Year Dollars	
1.2.1.2 POL - Other	3,590	4,298	1,203	0	
1.2.3.1 Equipment	37,220	67,604	21,372	9,747	
1.2.3.2 Consumables	166,867	144,188	164,565	139,933	
1.3.1 Printing & Copying Services	12,654	13,301	16,500	8,171	Provided by VAMOSC
1.3.2 ADP Rental & Contract Services	12,218	94,433	28,551	11,925	
1.3.4 Telephone & Postal Services	15,744	12,089	11,774	15,012	
1.1.3 TAD	20,501	11,377	9,105	23,236	
Total of VAMOSC provided data:	268,794	347,290	253,070	208,024	Total from VAMOSC
OPTAR other (SO)	269,000	347,000	253000	213,000	Provided by Comptroller

Table B.1. Yearly VAMOSC Total to Yearly OPTAR Other (SO) Comparisons

B. OPTAR OTHER (SO) FUND CODES TO VAMOSC SUB-CATEGORY TOTALS

Five cases were used to establish the relationship between the OPTAR other fund codes and the individual VAMOSC sub-elements. Each "case" was a boat in the Pacific fleet. The boats were picked to get at least one from each port and each squadron.

The column under the ship's name and hull number provides the applicable VAMOSC sub-element number and name. The next column, "VAMOSC" lists the values (in 2006$) that were in the database for those spending categories. The third column is the value from the applicable fund code or sum of fund codes from the 2006 BOR. The last column is the fund code or list of codes from the BOR that make the total in the third column. All values are in 2006 dollars.

In most cases a comparison of the VAMOSC column with the Comptroller's BOR column shows an exact match. In other cases they are slightly different. Again, these differences may be due to the timing of the reports. The BOR is assembled and reported in October, and it is possible that some late transactions might be missed. VAMOSC likely takes this into account through its data collection and database posting. The conclusion is that the VAMOSC sub-elements provide the same information as the OPTAR fund codes founding the BOR.

In some cases there is a direct one to one relationship. In other cases, the VAMOSC element data are a roll up of two or three OPTAR fund codes.

Los Angeles: SSN 688	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	9	8.67	M9
1.2.3.1 Equipment	18,029	17,784.06	ME+MJ
1.2.3.2 Consumables	125,544	124,160.00	MC+M7+M2
1.3.1 Printing & Copying Services	10,100	10,100.00	MV
1.3.2 ADP Rental & Contract Services	10,309	10,551.90	MU
1.3.4 Telephone & Postal Services	11,737	11,736.79	MS
1.1.3 TAD	28,252	28,656.88	MD

Corpus Christi: SSN 705	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	177	176.70	M9
1.2.3.1 Equipment	8,716	8,715.91	ME+MJ
1.2.3.2 Consumables	164,239	161,202.31	MC+M7+M2
1.3.1 Printing & Copying Services	7,361	7,166.37	MV
1.3.2 ADP Rental & Contract Services	3,816	2,742.75	MU
1.3.4 Telephone & Postal Services	3,851	3,515.72	MS
1.1.3 TAD	6,291	6,381.04	MD

Chicago: SSN 721	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	-4,528	4,494.00	M9
1.2.3.1 Equipment	8,331	7,753.93	ME+MJ
1.2.3.2 Consumables	192,431	193,931.18	MC+M7+M2
1.3.1 Printing & Copying Services	12,165	12,164.00	MV
1.3.2 ADP Rental & Contract Services	393	393.00	MU
1.3.4 Telephone & Postal Services	10,013	9,343.00	MS
1.1.3 TAD	9,779	9,919.14	MD

Jefferson City: SSN 759	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	14,297	14,297.34	M9
1.2.3.1 Equipment	5,795	5,794.78	ME+MJ
1.2.3.2 Consumables	229,854	230,240.53	MC+M7+M2
1.3.1 Printing & Copying Services	5,000	5,000.00	MV
1.3.2 ADP Rental & Contract Services	616	616.20	MU
1.3.4 Telephone & Postal Services	4,051	4,050.72	MS
1.1.3 TAD	0	0.00	MD

Cheyenne: SSN 773	VAMOSC (2006 $'s)	COMPTROLLER'S BOR (2006 $'s)	OPTAR Fund Code(s)
1.2.1.2 POL - Other	189	189.44	M9
1.2.3.1 Equipment	8,591	9,903.30	ME+MJ
1.2.3.2 Consumables	127,029	119,799.66	MC+M7+M2
1.3.1 Printing & Copying Services	0	0.00	MV
1.3.2 ADP Rental & Contract Services	23,176	23,176.26	MU
1.3.4 Telephone & Postal Services	17,829	17,436.94	MS
1.1.3 TAD	18,314	18,575.70	MD

Table B.2. VAMOSC sub-elements OPTAR Other Fund Code Comparisons

APPENDIX C: WILCOXON TEST SUMMARY TABLES

The statistical analysis program STATA 9 was used to perform the Wilcoxon Rank Sum test on samples taken year by year. Since there were only two ports (Pearl Harbor and San Diego) from 1996 to 2002, only these two are compared in each of those years. For fiscal year 2003 through fiscal year 2006, the test was repeated three times, once between San Diego and Pearl Harbor, once between Guam and Pearl Harbor, and once between Guam and San Diego. The data are grouped by the population comparisons. These year-by-year tests are displayed in sections A, B and C.

To analyze the aggregate samples with the Wilcoxon test, the method outlined in the Ross textbook pages 651-655 was used in conjunction with Microsoft Excel database function. These results are presented in section D.

A. PEARL HARBOR VERSUS SAN DIEGO

Total OPTAR									
San Diego Total OPTAR population vs. Pearl Harbor Total OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	SD count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
1996	8	13	100	88	190.67	0.3848	No	No	No
1997	5	18	67	60	180	0.6018	No	No	No
1998	4	18	62	46	138	0.1732	No	No	No
1999	6	18	72	75	225	0.8415	No	No	No
2000	6	17	99	72	204	0.0587	**Yes**	No	No
2001	6	18	39	75	225	0.0164	**Yes**	**Yes**	No
2002	6	18	64	75	225	0.4634	No	No	No
2003	7	16	59	84	224	0.0948	**Yes**	No	No
2004	6	17	75	72	204	0.8336	No	No	No
2005	6	17	79	72	204	0.6241	No	No	No
2006	4	17	45	44	124.67	0.9286	No	No	No

Repair OPTAR									
San Diego Repair OPTAR population vs. Pearl Harbor Repair OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	SD count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
1996	8	13	100	88	190.67	0.5623	No	No	No
1997	5	18	67	60	180	0.3711	No	No	No
1998	4	18	66	46	138	0.0887	**Yes**	No	No
1999	6	18	80	75	225	0.7389	No	No	No
2000	6	17	102	72	204	0.0357	**Yes**	**Yes**	No
2001	6	18	49	75	225	0.0830	**Yes**	No	No
2002	6	18	66	75	225	0.5485	No	No	No
2003	7	16	60	84	224	0.1088	No	No	No
2004	6	17	72	72	204	1.0000	No	No	No
2005	6	17	74	72	204	0.8886	No	No	No
2006	4	17	45	44	124.67	0.9286	No	No	No

Other OPTAR									
San Diego Other OPTAR population vs. Pearl Harbor Other OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	SD count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
1996	8	13	97	88	190.67	0.5145	No	No	No
1997	5	18	50	60	180	0.4561	No	No	No
1998	4	18	46	46	138	1.0000	No	No	No
1999	6	18	68	75	225	0.6407	No	No	No
2000	6	17	61	72	204	0.4412	No	No	No
2001	6	18	39	75	225	0.0077	**Yes**	**Yes**	**Yes**
2002	6	18	71	75	225	0.7897	No	No	No
2003	7	16	50	84	224	0.0231	**Yes**	**Yes**	No
2004	6	17	84	72	204	0.4008	No	No	No
2005	6	17	88	72	204	0.2626	No	No	No
2006	4	17	51	44	124.67	0.5307	No	No	No

B. GUAM VERSUS PEARL HARBOR

Total OPTAR									
Guam Total OPTAR population vs. Pearl Harbor Total OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	17	34	20	56.67	0.0629	**Yes**	No	No
2005	3	17	42	31.5	89.25	0.2664	No	No	No
2006	3	17	29	31.5	89.25	0.7913	No	No	No

Repair OPTAR									
Guam Repair OPTAR population vs. Pearl Harbor Repair OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	17	34	20	56.67	0.0629	**Yes**	No	No
2005	3	17	43	31.5	89.25	0.2235	No	No	No
2006	3	17	29	31.5	89.25	0.7913	No	No	No

Other OPTAR									
Guam Other OPTAR population vs. Pearl Harbor Other OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	17	30	20	56.67	0.1840	No	No	No
2005	3	17	26	31.5	89.25	0.5604	No	No	No
2006	3	17	19	31.5	89.25	0.1858	No	No	No

C. GUAM VERSUS SAN DIEGO

Total OPTAR									
Guam Total OPTAR population vs. San Diego Total OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	SD count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	6	14	9	9	0.0956	**Yes**	No	No
2005	3	6	15	15	15	1.0000	No	No	No
2006	3	4	10	12	8	0.4795	No	No	No

Repair OPTAR									
Guam Repair OPTAR population vs. San Diego Repair OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	SD count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	6	14	9	9	0.0956	**Yes**	No	No
2005	3	6	17	15	15	0.6056	No	No	No
2006	3	4	10	12	8	0.4795	No	No	No

Other OPTAR									
Guam Other OPTAR population vs. San Diego Other OPTAR population									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
FY	GU count (n)	SD count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
2004	2	6	12	9	9	0.3173	No	No	No
2005	3	6	12	15	15	0.4386	No	No	No
2006	3	4	9	12	8	0.2888	No	No	No

D. AGGREGATE LEVEL ANALYSIS PORT VS. PORT

San Diego populations vs. Pearl Harbor populations									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
	SD count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
Total OPTAR	64	187	7994	8064	251328	0.8897	No	No	No
Repair OPTAR	64	187	8194	8064	251328	0.7962	No	No	No
Other OPTAR	64	187	7461	8064	251328	0.2294	No	No	No

Guam populations vs. Pearl Harbor populations									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
	GU count (n)	PH Count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
Total OPTAR	9	187	1005	886.5	27629.25	0.4778	No	No	No
Repair OPTAR	9	187	1086	886.5	27629.25	0.2312	No	No	No
Other OPTAR	9	187	378	886.5	27629.25	0.0022	**Yes**	**Yes**	**Yes**

Guam populations vs. San Diego populations									
Test: H_o: Samples come from the same population. H_1: Samples come from different populations.									
							Significant at		
	GU count (n)	SD count (m)	TS	Ave TS	TS Var	p-value	90%?	95%?	99%?
Total OPTAR	9	64	429	333	3552	0.1091	No	No	No
Repair OPTAR	9	64	458	333	3552	0.0367	**Yes**	**Yes**	No
Other OPTAR	9	64	213	333	3552	0.045	**Yes**	**Yes**	No

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APPENDIX D: COST ELEMENT STRUCTURES FOR THE OTHER OPTAR CATEGORY

A. AGGREGATE COST ELEMENT STRUCTURE (CES) TABLES

The two tables labeled Table D.1, present the average amounts spent on each Other OPTAR category for each of the three ports. The averages were calculated using all the observations over all eleven years of data.

The upper table has the values of the averages expressed in FY 2006 dollars. The lower table is simply a vertical analysis done by dividing the average for the respective spending category by the Other OPTAR total.

	Pearl Harbor	San Diego	Guam
Other OPTAR total	315,089	281,780	218,554
Telephone/Postal	11,827	5,259	7,768
ADP renatals/Contracts	59,605	50,791	14,061
Printing/Copying	10,366	5,734	3,815
TAD	17,110	7,858	1,624
Consumables	169,773	163,957	170,909
Equipment	36,708	34,126	18,821
Other POL	10,058	15,085	1,556
	(Values expressed in FY 2006 $'s)		

	Pearl Harbor	San Diego	Guam
Other OPTAR total	100%	100%	100%
Telephone/Postal	4%	2%	4%
ADP renatals/Contracts	19%	18%	6%
Printing/Copying	3%	2%	2%
TAD	5%	3%	1%
Consumables	54%	58%	78%
Equipment	12%	12%	9%
Other POL	3%	5%	1%
	(Values are % of Other OPTAR total)		

Table D.1. Other OPTAR Cost Element Structures for each port (based upon all observations)

B. YEARLY COST ELEMENT STRUCTURE (CES) TABLES

The following three tables (Table D.2) present the *yearly* average amounts spent on each Other OPTAR category by port. The averages were calculated using all the observations for each particular port in that respective year.

The upper, middle and lower tables are the values for Pearl Harbor, San Diego and Guam, respectively.

Pearl Harbor (Average yearly expenditures, FY2006 $'s)											
Fiscal Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Other OPTAR total	288,117	332,658	328,723	360,882	350,276	436,770	317,860	383,175	239,358	219,463	194,507
Telephone/Postal	5,776	6,688	8,514	10,412	13,679	16,678	15,586	16,841	12,367	10,743	11,762
ADP renatals/Contracts	62,372	69,177	62,225	69,443	59,855	98,284	87,036	95,021	17,395	20,429	11,963
Printing/Copying	6,586	11,867	9,352	10,819	13,450	12,894	13,935	11,778	9,810	6,612	5,702
TAD	21,007	13,494	13,840	18,362	21,230	27,045	17,067	17,523	14,188	12,995	12,154
Consumables	135,204	175,944	169,243	190,905	189,448	211,499	146,690	187,623	162,277	149,306	139,606
Equipment	46,892	44,349	46,176	54,557	43,300	57,264	24,273	42,998	18,656	14,874	11,735
Other POL	10,280	11,140	21,794	9,414	9,314	13,107	13,273	11,393	4,665	4,503	1,684

San Diego (Average yearly expenditures, FY2006 $'s)											
Fiscal Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Other OPTAR total	326,401	277,038	311,164	341,609	333,423	291,190	257,845	246,514	245,388	227,352	221,605
Telephone/Postal	5,973	4,303	2,993	3,825	10,072	5,273	13,701	2,390	680	2,634	5,376
ADP renatals/Contracts	88,882	56,080	46,194	76,780	90,595	55,726	73,922	18,103	19,598	9,080	4,859
Printing/Copying	7,385	2,092	3,841	3,582	4,778	8,511	6,472	7,183	7,453	5,532	3,460
TAD	14,629	8,783	6,007	6,913	11,543	9,822	15,853	3,147	16	4,734	651
Consumables	144,230	153,654	181,731	207,522	185,877	163,828	113,387	166,802	166,835	154,386	181,390
Equipment	45,209	33,455	55,065	39,915	17,770	35,452	17,810	34,294	38,283	35,245	21,989
Other POL	20,094	18,672	15,333	15,869	12,789	12,578	16,700	14,594	12,523	15,743	5,174

Guam (Average yearly expenditures, FY2006 $'s)			
Fiscal Year	2004	2005	2006
Other OPTAR total	287,701	214,285	168,275
Telephone/Postal	8,118	7,124	4,887
ADP renatals/Contracts	9,614	10,514	12,487
Printing/Copying	8,007	3,689	2,419
TAD	517	1,118	2,754
Consumables	244,581	157,875	137,555
Equipment	16,865	29,398	8,105
Other POL	0	4,565	67

Table D.2. Other OPTAR Cost Element Structures for each port (year-by-year)

C. GRAPHS OF YEARLY COST ELEMENT STRUCTURE AVERAGES

The following three charts (Figure D.1, Figure D.2 and Figure D.3) are graphical representations of the tables in Table D.2.

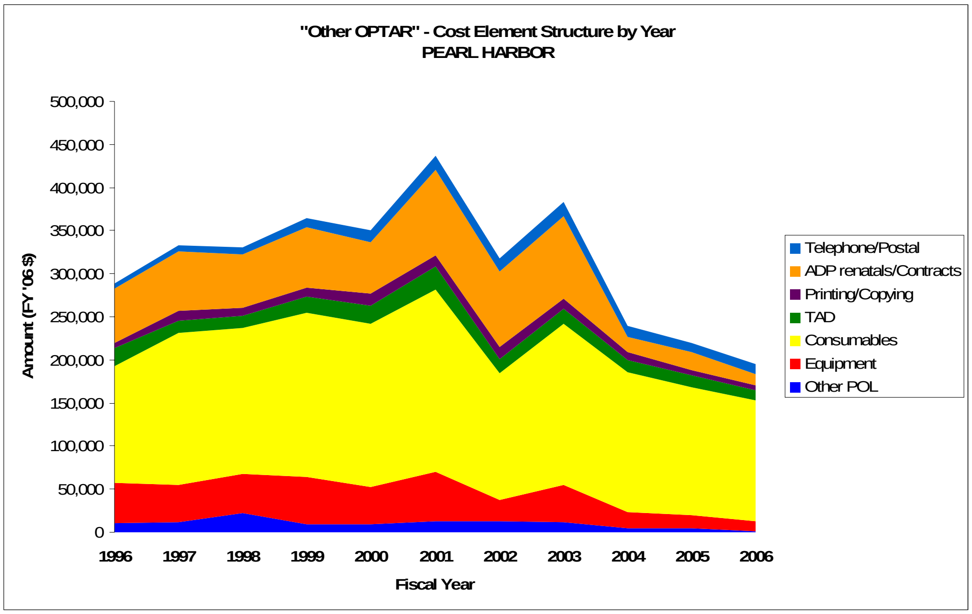

Figure D.1. Cost Element Structures for Pearl Harbor 1996-2006

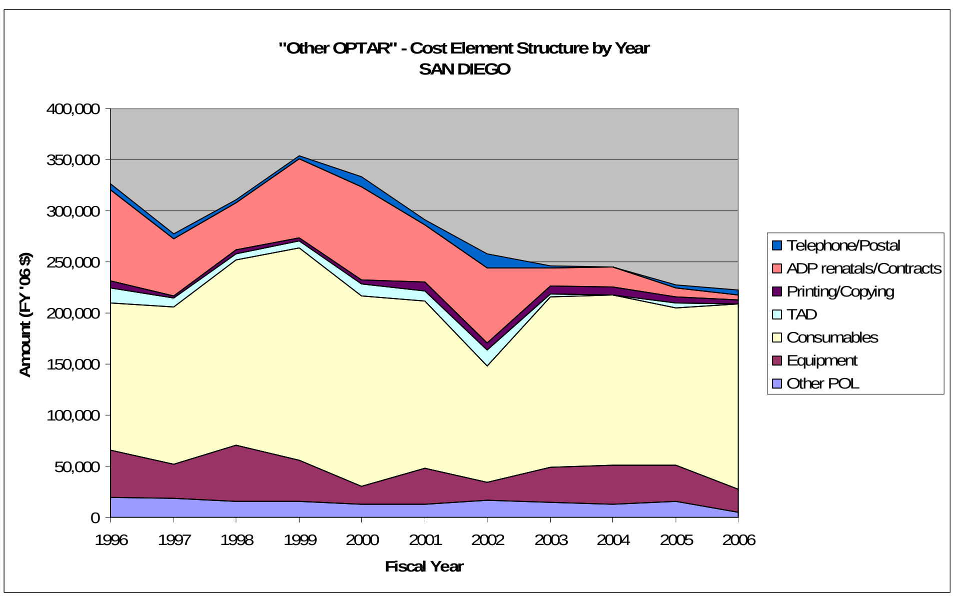

Figure D.2. Cost Element Structures for San Diego 1996-2006

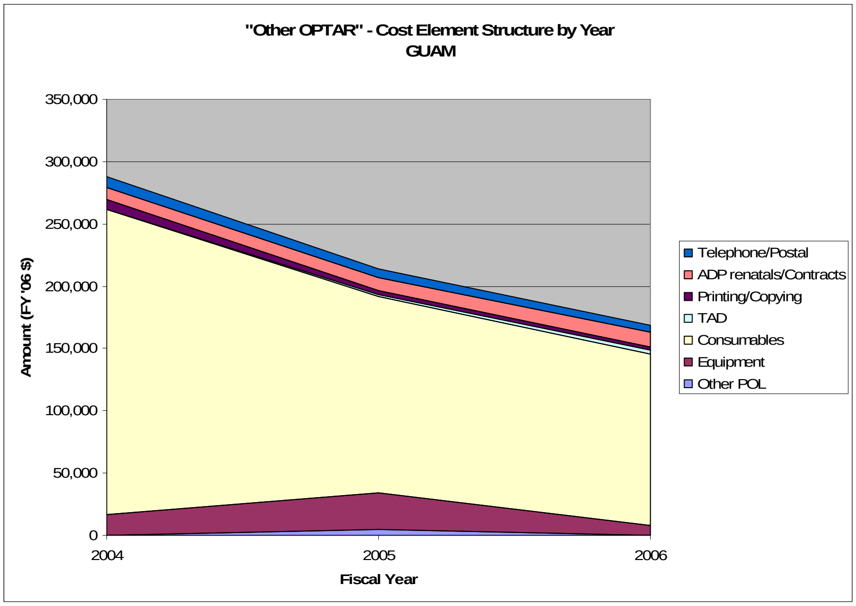

Figure D.3. Cost Element Structures for Guam 2004-2006

D. GRAPHS OF YEARLY COST ELEMENT STRUCTURE VERTICAL ANALYSES

The following three charts (Figure D.4, Figure D.5 and Figure D.6) are the vertical analysis of the three tables found in Table D.2. The entire y-axis represents the Total of Other OPTAR spending. Each category takes up the percent amount of its contribution to the total.

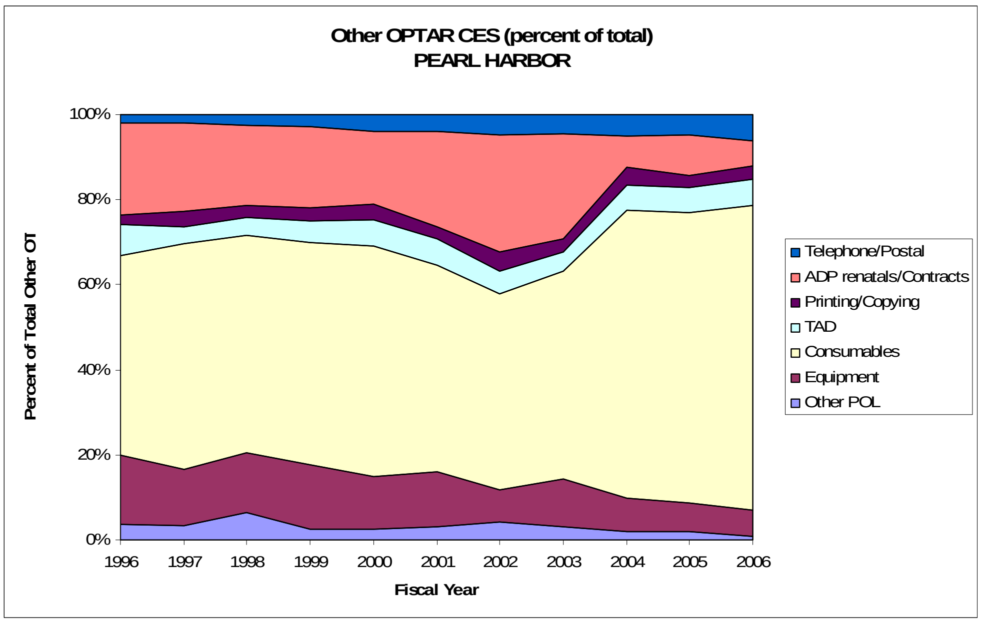

Figure D.4. Cost Element Structures for Pearl Harbor 1996-2006 (Vertical Analysis)

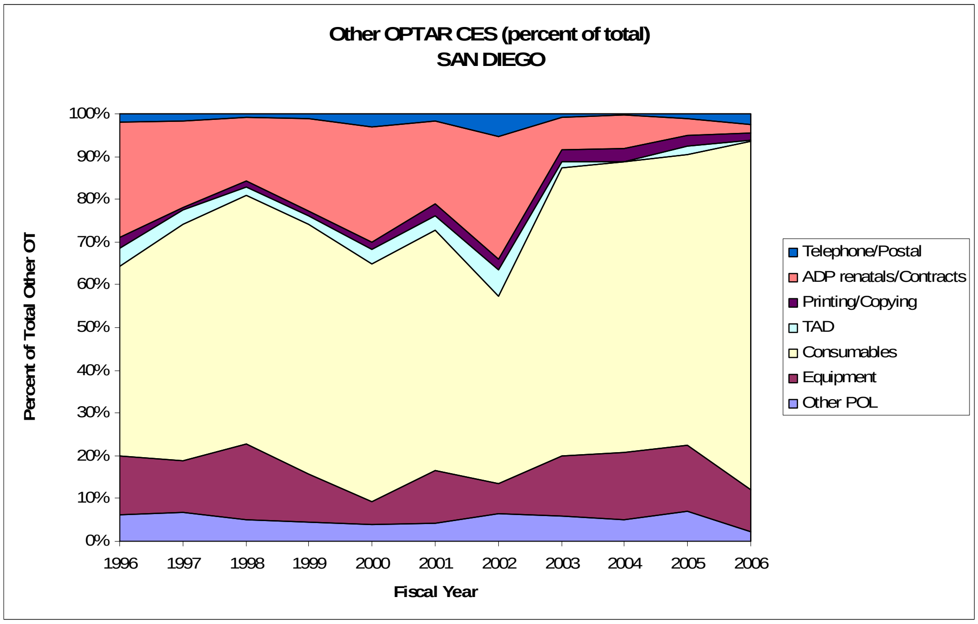

Figure D.5. Cost Element Structures for San Diego 1996-2006 (Vertical Analysis)

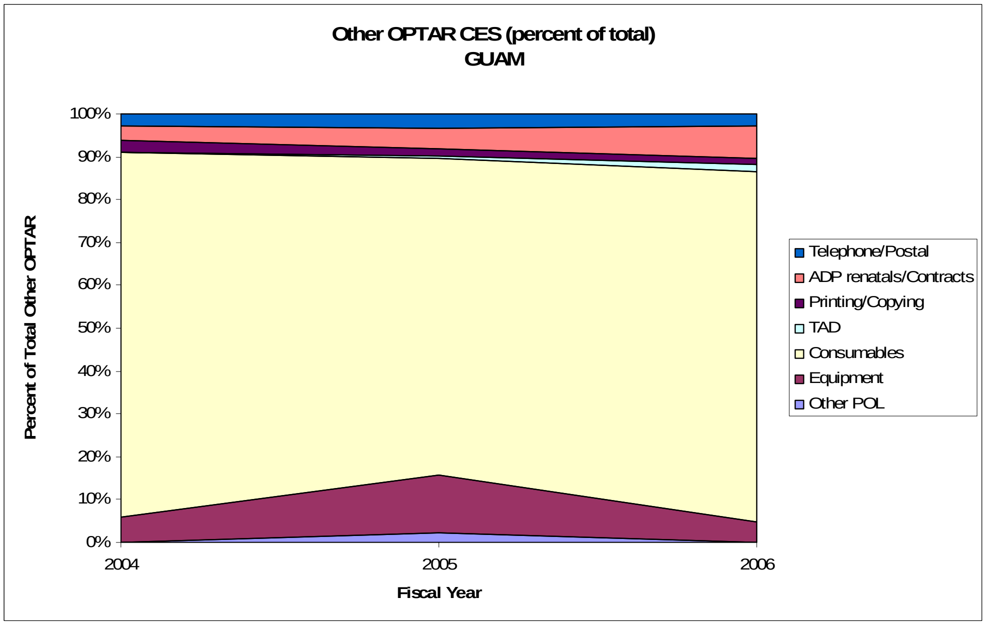

Figure D.6. Cost Element Structures for Guam 2004-2006 (Vertical Analysis)

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